An Observer's Report of the NORPAX/FGGE Oceanographic Expedition Between Hawaii and Tahiti.

by: Bjørn R. Aune,
University of Hawaii
at Manoa
Honolulu, Hawaii
July 1981

Table of Contents.

Forward and Acknowledgements.

The following report is on the NORPAX/FGGE oceanographic research expedition which was conducted from February 1979 to June 1980.NORPAX/FGGE is an abbreviation for the North Pacific Experiment which is a subgroup of the First Global GARP Experiment.GARP is a abbreviation for the Global Atmospheric Report Program.The research project was conducted as part of the International Decade of Ocean Exploration.The nineteen seventies (1970's) were declared a decade of ocean exploration in order to promote international cooperation and participation in learning about the oceans and ocean-atmosphere relationships.

All the subject matter contained in this report are observations by the author. The viewpoints expressed in the report are also those of the author.The author had the privilege of participating in the last quarter of the NORPAX/FGGE experiment and is thankful to all those involved for the opportunity.

The NORPAX/FGGE experiment was conducted between Hawaii and Tahiti.The experiment consisted of a series of fifteen legs between the two places.The research vessels utilized in the experiment were the R/V Gyre from Texas A & M and the R/V Wecoma from Oregon State University.The course of the expedition is on pages 41 and 68 of the report.There were slight deviations from the courseline but for the majority of the experiment the courseline depicted is correct.

The author would like to particularly acknowledge the assistance given by the following people in making this report possible: Dr. Klaus Wyrtki of the University of Hawaii Department of Oceanography;Dr. Eric Firing of the Hawaii Institute of Geophysics;Dr. Bruce Taft of the University of Washington School of Oceanography;Dr. Louis Gordon of Oregon State University School of Oceanography;Mrs. Sue Hampsom, Coordinator of the University of Hawaii Marine Option Program;and the crew of the research vessel Wecoma.

I

The Ship.

The research vessel utilized in the NORPAX/FGGE experiment was the R/V Wecoma. The R/V Wecoma,which belongs to Oregon State University (OSU),is a low profile vessel built with the lines of a cutter and designed specifically as a research vessel.

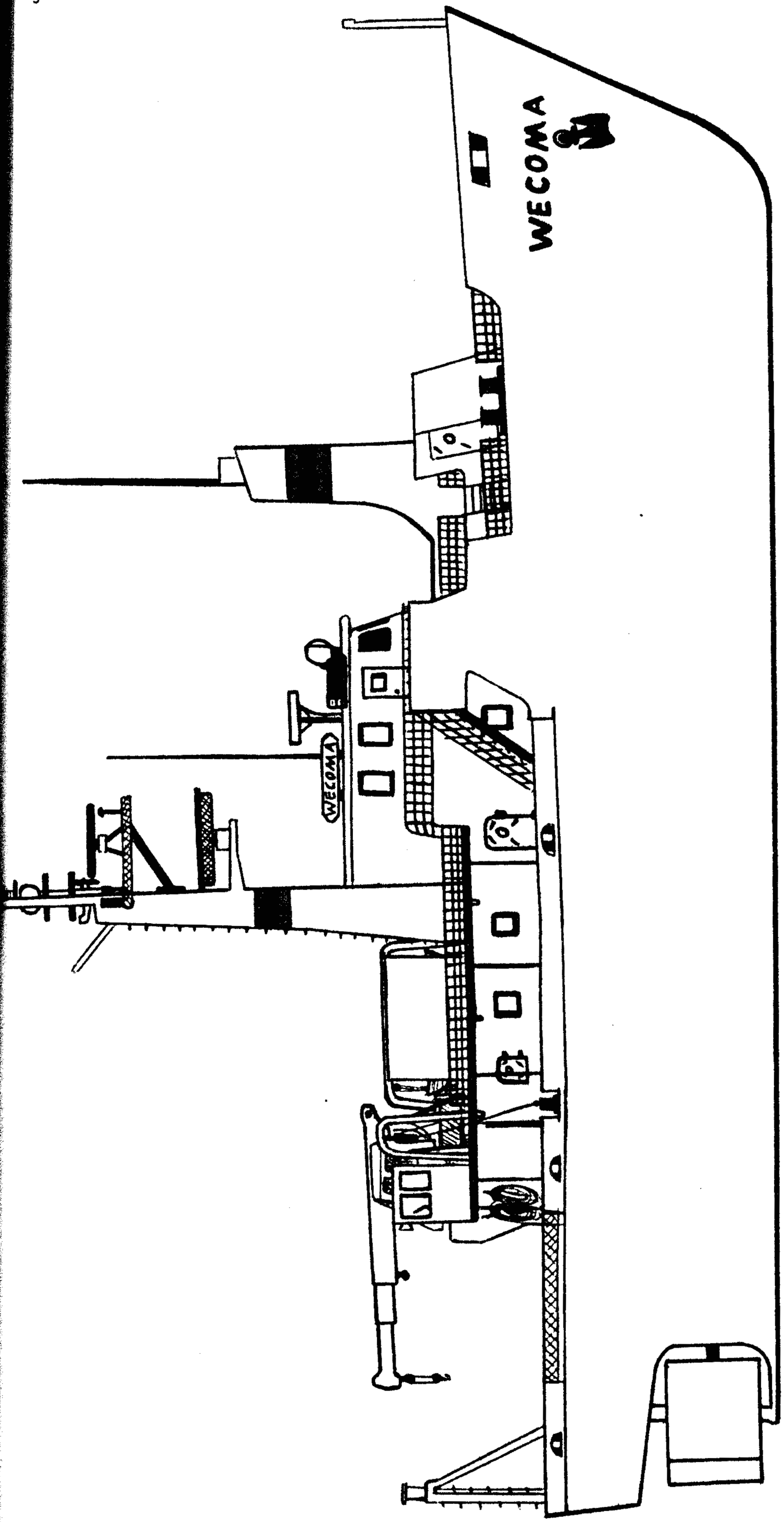
The birthplace of the R/V Wecoma,along with two sister ships,was Peterson Builders Inc.,Sturgeon Bay,Wisconsin.The R/V Wecoma was launched in May of 1975 and delivered to OSU in November of the same year.

Since the R/V Wecoma is a research vessel exclusively,she has been designed with specific appropiate structure and equipment that facilitates her role as a research vessel.The R/V Wecoma will be examined from this point of view beginning with the keel and up to the mast.Before doing this,the vessel's general statistics will be reviewed.

As shown on the following page (Figure 1-1),the R/V Wecoma was basically designed with the lines of a cutter.She is classified as an "intermediate size research ship." The over-all length of the R/V Wecoma is 177 feet with a beam of 37 feet (see Figure 1-2).The vessel has a maximum allowable draft of 17.5 feet.However the general operational draft is 15-16 feet.The displacement tonnage of the vessel is 962 tons.At the lowest open deck level (deck closest to the waterline) which is the fantail,the freeboard (distance between deck and waterline) is 5 feet.The maximum speed capability is 15.5 knots.General operational speed however is 11-13 knots.The vessel has an operating range of 8,000 miles with an endurance limit of 30 days.The endurance limit is the maximum amount of time,in days,that the fuel supply,water supply,and food supply would last with a full complement of crew and normal consumption.It is the limiting fuel factor that is responsible for the vessel using lower operating speeds.The vessel needs a crew complement of 13 to operate her properly.

The R/V Wecoma was built with a low profile bridge located just forward of midships and a high forward deck.The forward deck is not used for any purpose except the windlass and anchors.The reason for the high forward deck and bow is to protect the superstructure and stern from the seas.The vessel would face into the seas when

Figure 1-1.

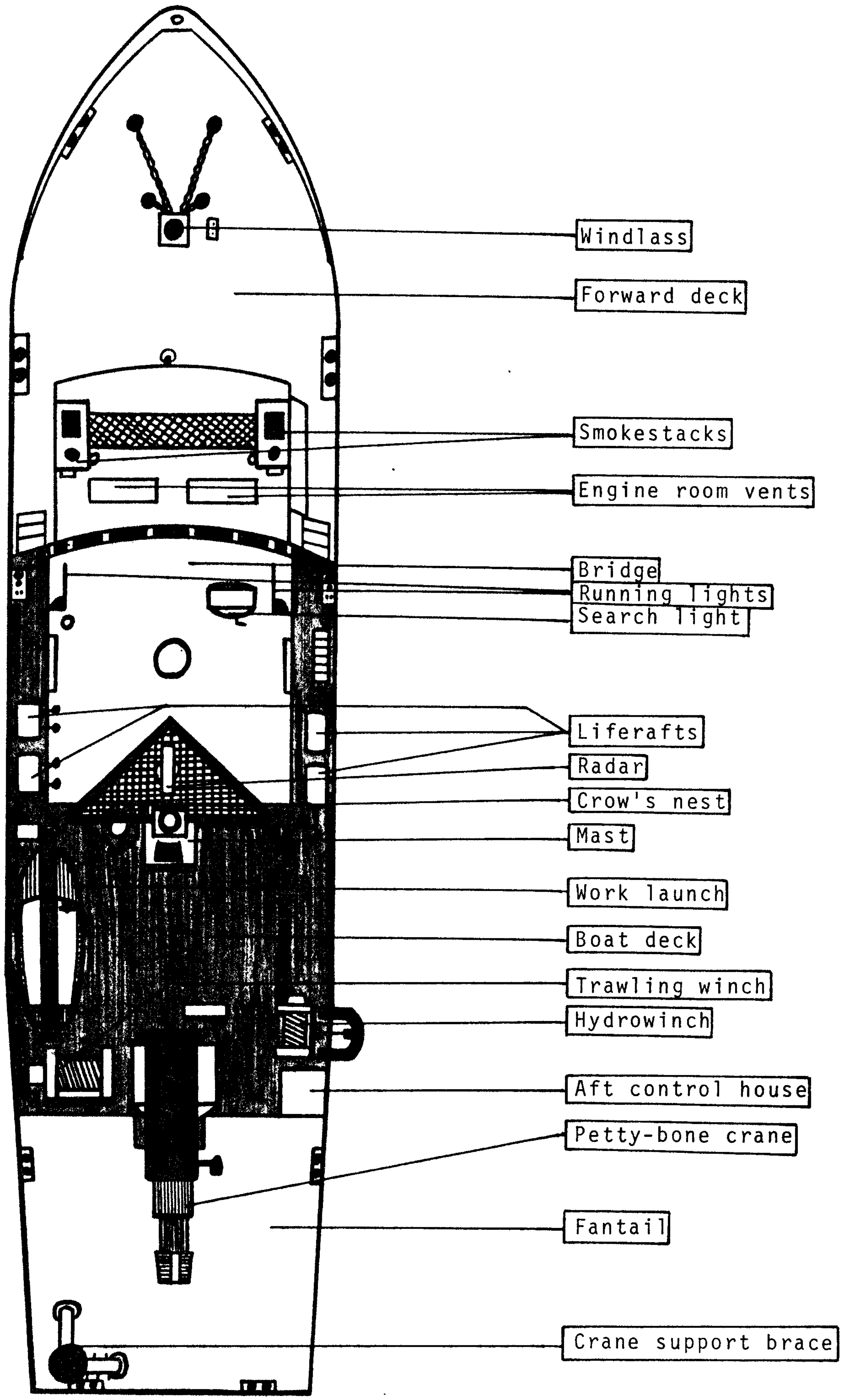


R/V WECOMA

scale: 1 inch = 17.7 feet

(side view)

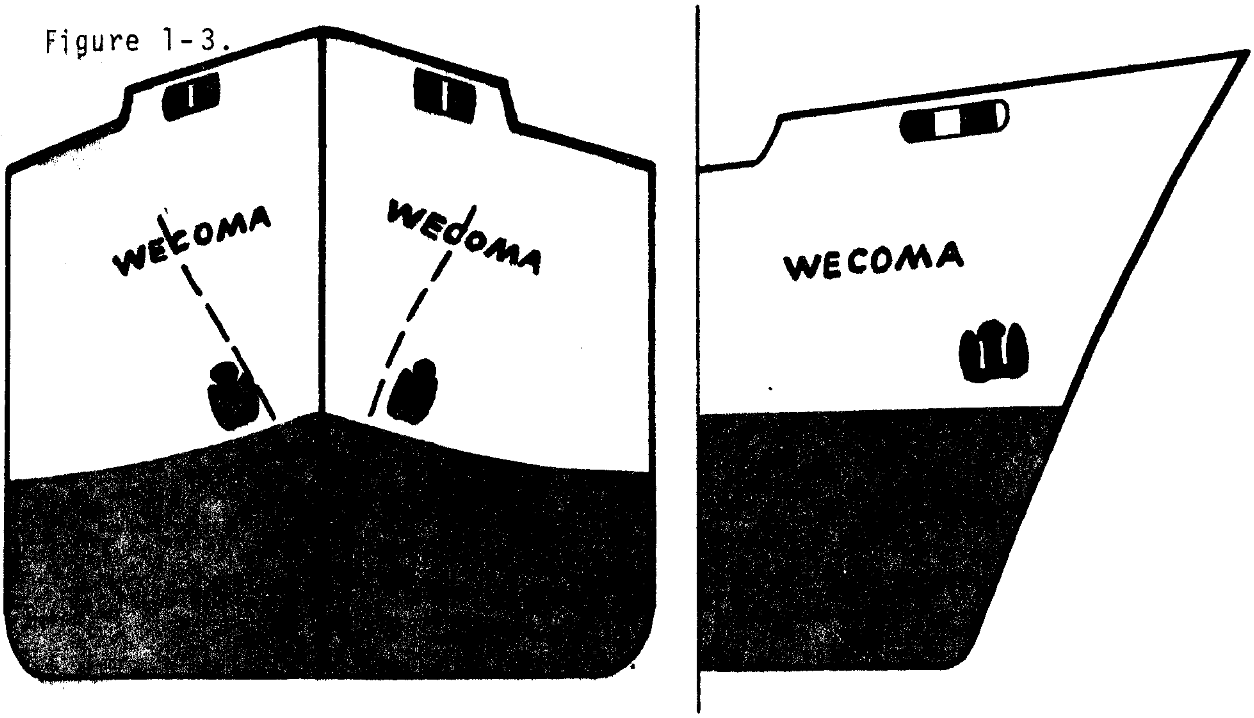
Figure 1-2.



Windlass
Forward deck
Smokestacks
Engine room vents
Bridge
Running lights
Search light
Liferafts
Radar
Crow's nest
Mast
Work launch
Boat deck
Trawling winch
Hydrowinch
Aft control house
Petty-bone crane
Fantail
Crane support brace

experiments were to be conducted.As shown below in Figure 1-3,the bow is wedge shaped with a high forward rake that permits the vessel to ride into the seas and break them away from the vessel.This keeps the seas from swamping the vessel and splashing water

Figure 1-3.

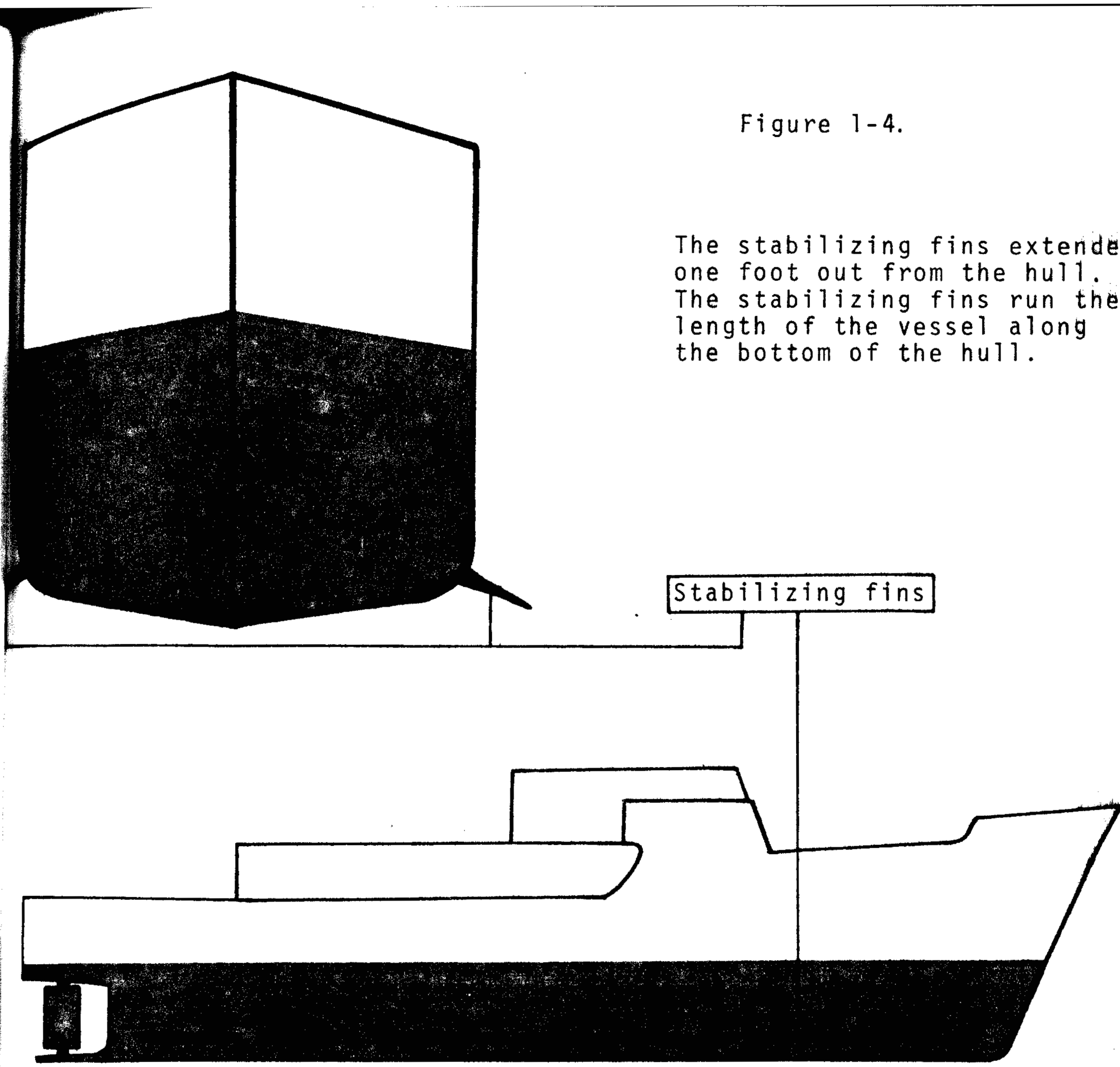


over the deck and creating hazardous working conditions.This concludes the examination of the vessel's general statistics.The vessel is similar to most other vessels as far as general structure and operating methods are concerned.The same basic equipment that can be found on any other vessel is also found on the R/V Wecoma.The same steel construction methods used on other vessels were also used on the R/V Wecoma.The differences are particular structure and style,as mentioned previously with the bow,and specific equipment that make the R/V Wecoma a research vessel.These differences will now be examinined in detail.

The keel and hull of the R/V Wecoma are structured the same as most other vessels. The keel runs the length of the ship from the bow to the propeller shaft.The hull has a streamlined design that promotes maximum efficiency of water flow as the vessel moves through the water.One unique feature is the stabilizing fins running the length of the ship along the ship's bottom where the hull bottom is widest.As shown in Figure 1-4 on the following page,the stabilizing fins protrude outwards at an angle that minimizes roll and maximizes stability.These stabilizing fins,also known as rolling chaulks,per-

Figure 1-4.

The stabilizing fins extended one foot out from the hull. The stabilizing fins run the length of the vessel along the bottom of the hull.

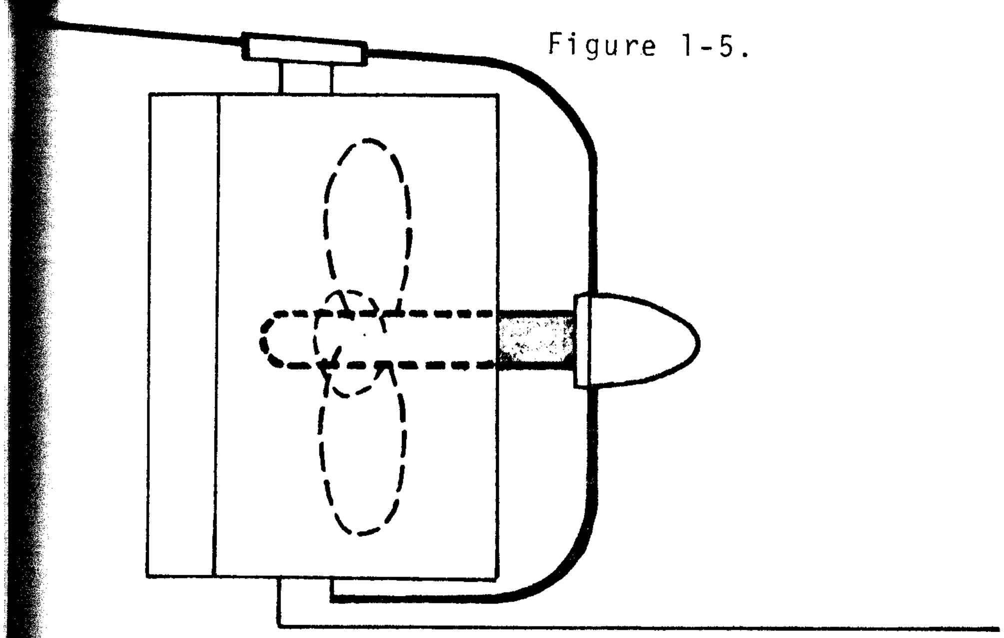


Stabilizing fin (starboard side)

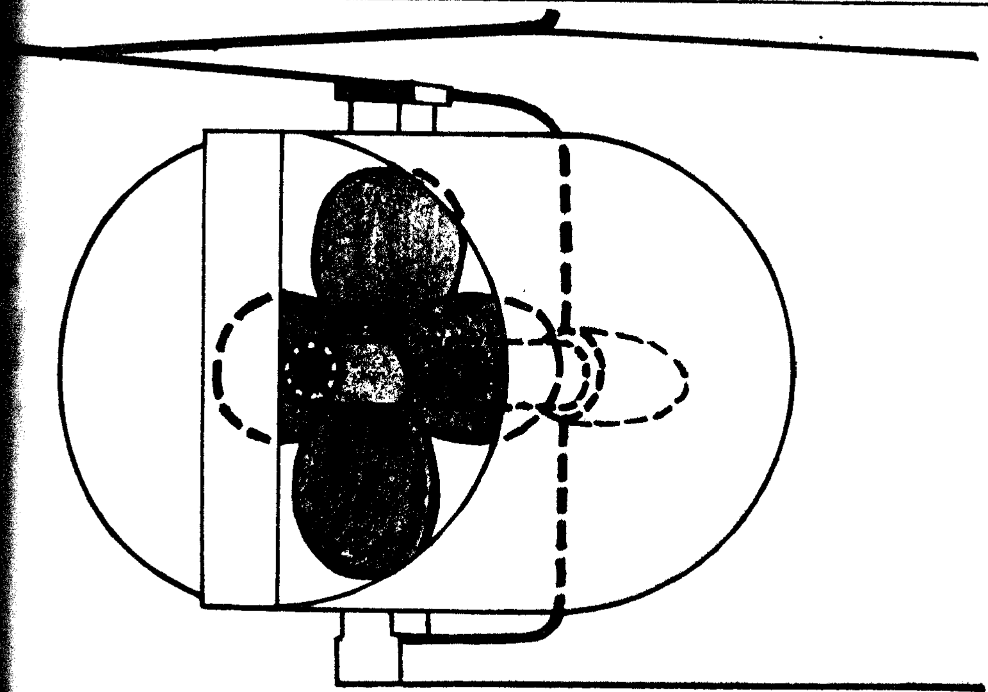
mit the vessel to ride evenly (minimum amount of roll) through rough seas as well as allow scientific experiments to be conducted in a safe and operable manner.By having these stabilizing fins,the R/V Wecoma is much more prepared for research work.

The R/V Wecoma utilizes a Kort nozzle which serves as the rudder.The Kort nozzle is a unique steering system that maximizes efficiency of propulsion.As shown in Figure 1-5 on the following page,the Kort nozzle is a round drum surrounding the propeller that can be directed in different directions depending on which way the vessel wishes to go.The Kort nozzle focusses the propelled water into a stream of rushing water that provides a thrust.It is this focussed stream of water that moves the vessel.By rotating the Kort nozzle on it's axis, which is the tiller shaft,the vessel can be manuevered.

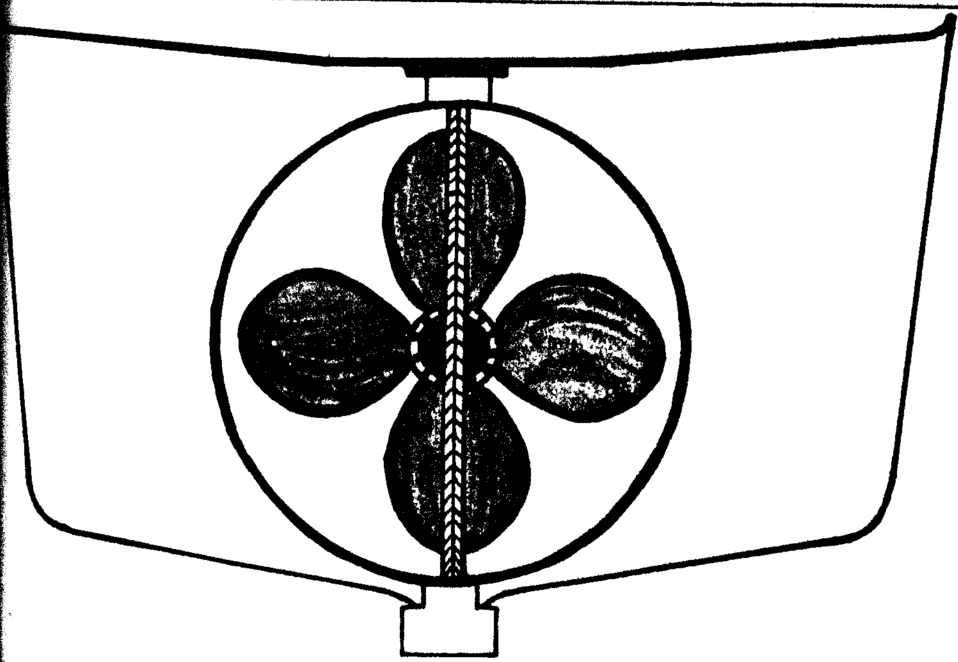
Figure 1-5.



Kort nozzle
as seen from
a side view.



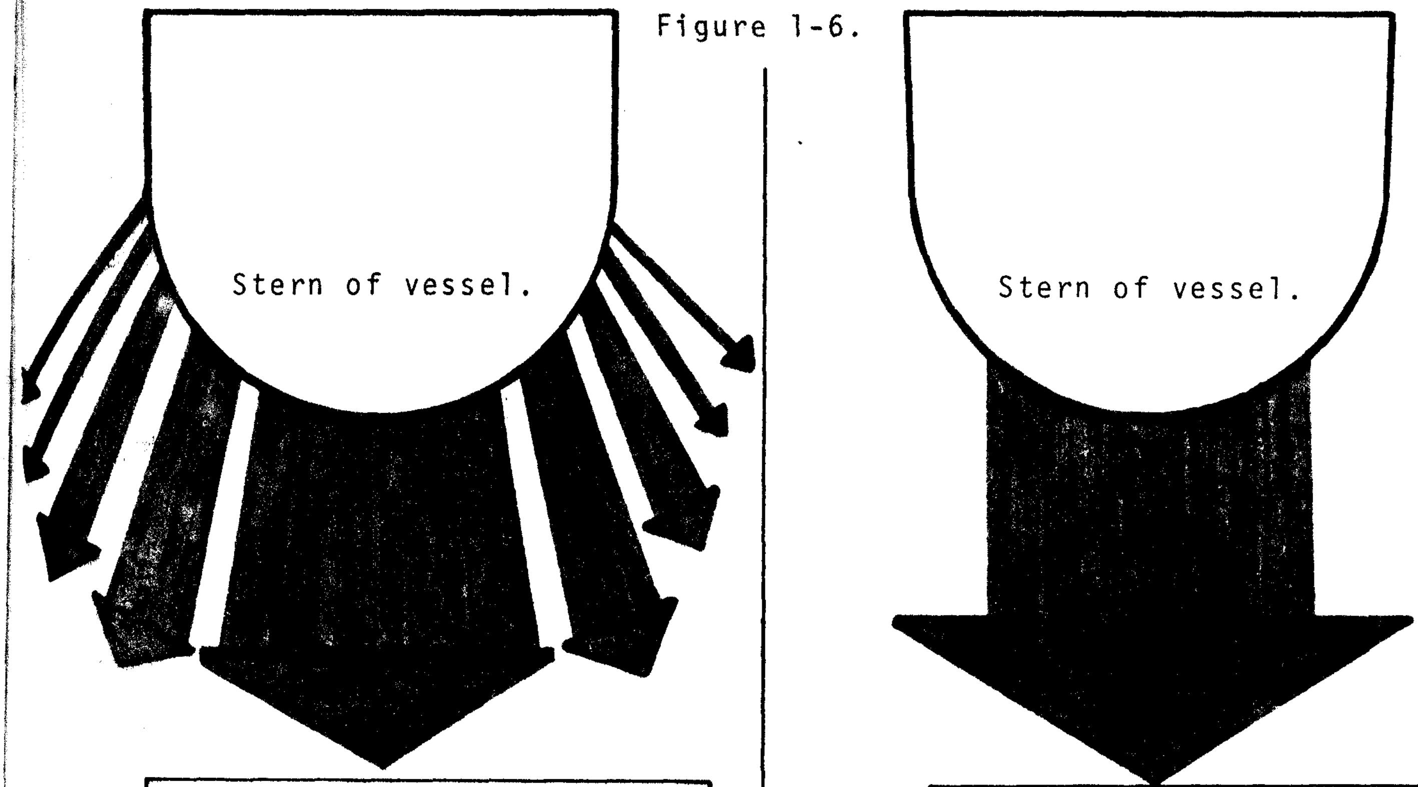
Kort nozzle
as seen from
a starboard
quarter view.



Kort nozzle
as seen from
a stern view.

In other words,the Kort nozzle directs the focussed stream of water in a certain direction and the ship's heading will come about.The Kort nozzle serves to eliminate wasteful water propulsion of the conventional steering system.The conventional steering system has a diffused water thrust since the propeller is not surrounded as it is in the Kort nozzle system.Diffused water thrust refers to the spread out (see Figure 1-6 below) stream of water that the propeller makes with the conventional steering

Figure 1-6.



Diffused thrust by the conventional propulsion and steering system.Since the propeller is no enclosed,the thrust of the propelled water is spread out and therefore lacks the strength of the Kort nozzle system.

Focussed thrust of the Kort nozzle propulsion and steering system.The propeller is enclosed in the Kort nozzle.The propelled water is therefore focussed as a water stream that yields more thrust.

system.It has been determined that the Kort nozzle system provides a 12% greater pro- *1
pulsion efficiency than the conventional system.It must be noted however that the Kort nozzle sytem has some drawbacks.With slow speeds,the Kort nozzle is not very effective as a rudder.This is because there is not enough water thrust that can be directed by the Kort nozzle to effectively manipulate the vessel's heading.The focussed stream of

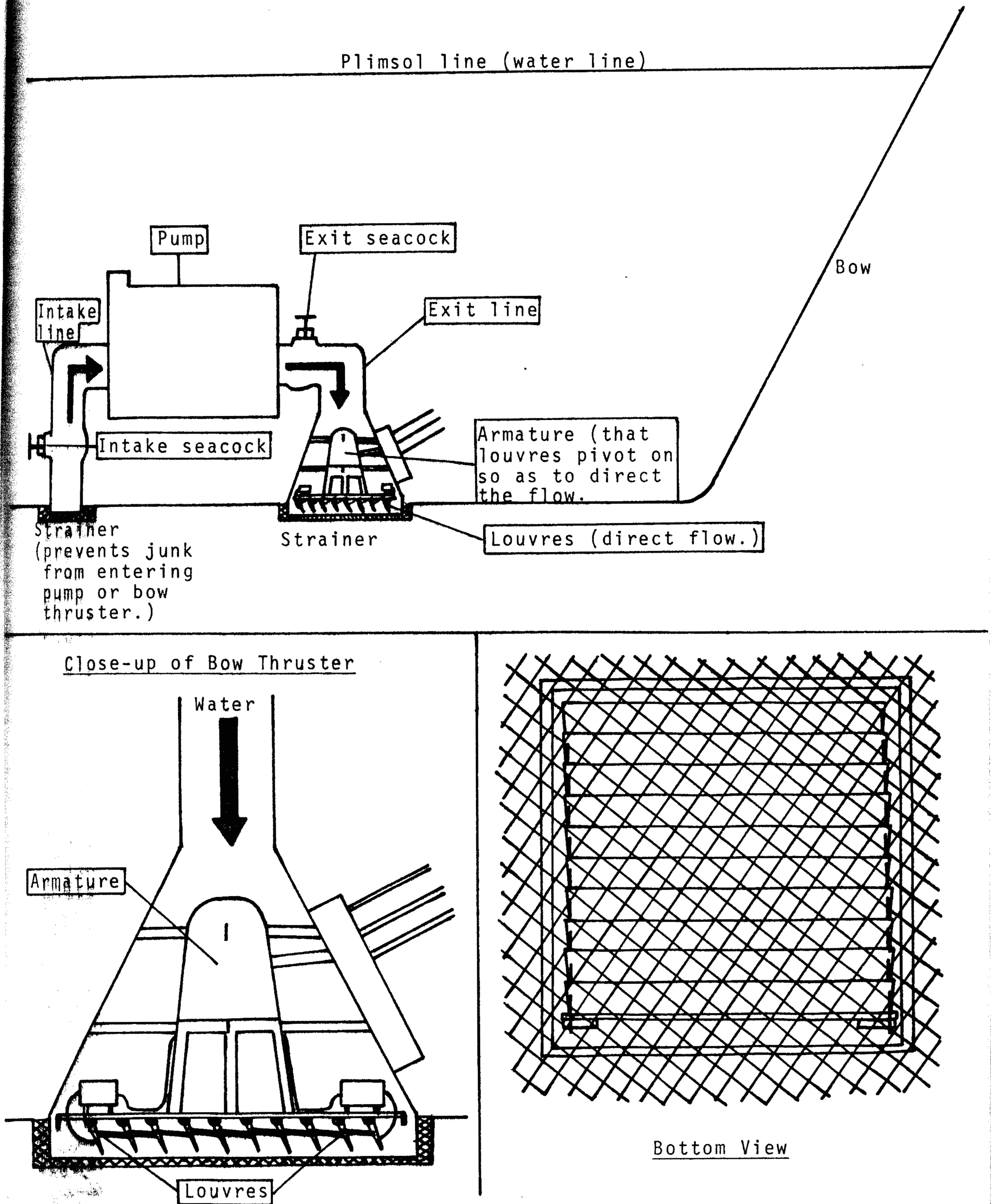
* The effectiveness of the Kort nozzle has been demonstrated in tests conducted in propulsion laboratories and at sea.

water produced by the propeller inside the Kort nozzle no longer exsists at slow speeds and therefore the Kort nozzle has nothing to direct.Also,the vessel can not back up (go astern) with much control over the steering.This is because the water thrust is reversed and there is no rudder to direct the water stream.The Kort nozzle now becomes an obstruction since the water stream is pulled through it towards the propeller.The Kort nozzle can not direct the vessel's reversed heading and guide it through the water as the conventional rudder would.Because the R/V Wecoma needs a good reversing capability as well as good positioning ability,the vessel is equipped with a bow thruster.As a research vessel,the R/V Wecoma has to have the ability to maintain position so that experiments can be conducted properly.Many times slow speeds are required for counter-acting currents or doing plankton trawls.

The R/V Wecoma is equipped with a 360° bow thruster that is able to easily adjust the vessel's position.The bow thruster is located on the ship's bottom near the bow as it name indicates.As shown in Figure 1-7 on the following page,the bow thruster operates on the principle of pumping water with such force as to produce motion.The pump will suck in water through the intake line and seacock and pump it back out with force through the exit line and seacock.The velocity with which the water is pumped determines the speed of movement of the vessel.The direction of movement of the vessel is determined by the rotating vanes inside the exit line.The vanes can be adjusted in any direction (360°) and at any angle up to 89° difference from the vertical.At 90°,the vanes would be closed since the vanes would be parallel to the ship's bottom.The vanes are located inside the bottom plate of the hull in the exit line.When water is pumped through the bow thruster,the vanes direct the flow of the exiting water as it exits the line.The vessel will move in a direction opposite to the bow thruster's thrust.The bridge controls have been adjusted so that the vessel will move in the desired direction when the bow thruster is used.

The concept of vanes directing water flow is analogous to a system of louvres directing air flow in an air conditioner or venetian blinds adjusting the amount of sunlight let in to a room.By this system of pumping water and directing its outflow,the bow thruster is a very handy device for manuevering a vessel.Coupled together with the Kort

Figure 1-7.



Plimsol line (water line)
Pump
Exit seacock
Intake line
Exit line
Bow
Intake seacock
Armature (that louvres pivot on so as to direct the flow.
Strainer (prevents junk from entering pump or bow thruster.)
Strainer
Louvres (direct flow.)
Close-up of Bow Thruster
Water
Armature
Louvres
Bottom View

nozzle,these two devices made the R/V Wecoma a very manageable vessel.In the event of an emergency,the bow thruster has enough power so that it can serve as the main propulsion unit.Examples of an emergency are engine failure of the main engine,cracked shaft, or lost propeller.

The R/V Wecoma is a single screw vessel.It utilizes a four (4) bladed variable pitch propeller.This type of propeller allows greater control over the propulsion of the vessel.By adjusting the pitch of the propeller,the vessel's speed is regulated.In addition,the vessel can go astern by simply adjusting the propeller blades to slice the water in reverse.Having a variable pitch propeller eliminates the need for a large gear reduction system on the main engine which saves space and time.The change of direction and speed of the vessel can be done more efficiently and with a lot less trouble.

The R/V Wecoma is equipped with a V-16 EMD General Motors turbocharged engine.The reason for having this engine is that it is inherently balanced which minimizes vibration and it is quiet.These two advantages are needed on a research vessel where experiments may depend on no noises or vibrational interference.Vibrational interference may either be physical,mechanical,or electrical,or a combination of the three.Also,maximum quiet induces pleasant working conditions for the people involved.

The engine is able to deliver a maximum speed of 15.5 knots at 900 RPM's (revolutions per minute) with an output of 2860 horsepower on the shaft when the propeller pitch is set to maximum propulsion.

The engine is located up forward next to the bow thruster.The reason for having the engine there is to eliminate the little noise and vibration that the engine does make from the laboratories and sleeping quarters back aft.

Electricity is provided by two (2) Caterpillar generators that are capable of producing 300 kilowatts of alternating current.Electricity is heavily needed to operate the vessel's equipment plus the many scientific instruments.The electricity is provided at many different voltages and as direct current so as to be able to accommodate all the different electrical appliances and machinery that may be used in research work. *2

* The R/V Wecoma carried over forty (40) extra electrical instruments and devices that required massive continuous consumption of electricity in order to do the experiments.

Fuel is stored in the fuel tanks beneath the lower deck (see Figure 1-9).The R/V Wecoma's fuel tanks are able to carry 56,000 gallons of fuel (diesel).The R/V Wecoma burns approximately 1,866 gallons per day.The daily fuel allotment is transferred to the day tanks where it is fed to the main engine and generators.By doing this,careful record of the fuel consumption rate can be maintained.

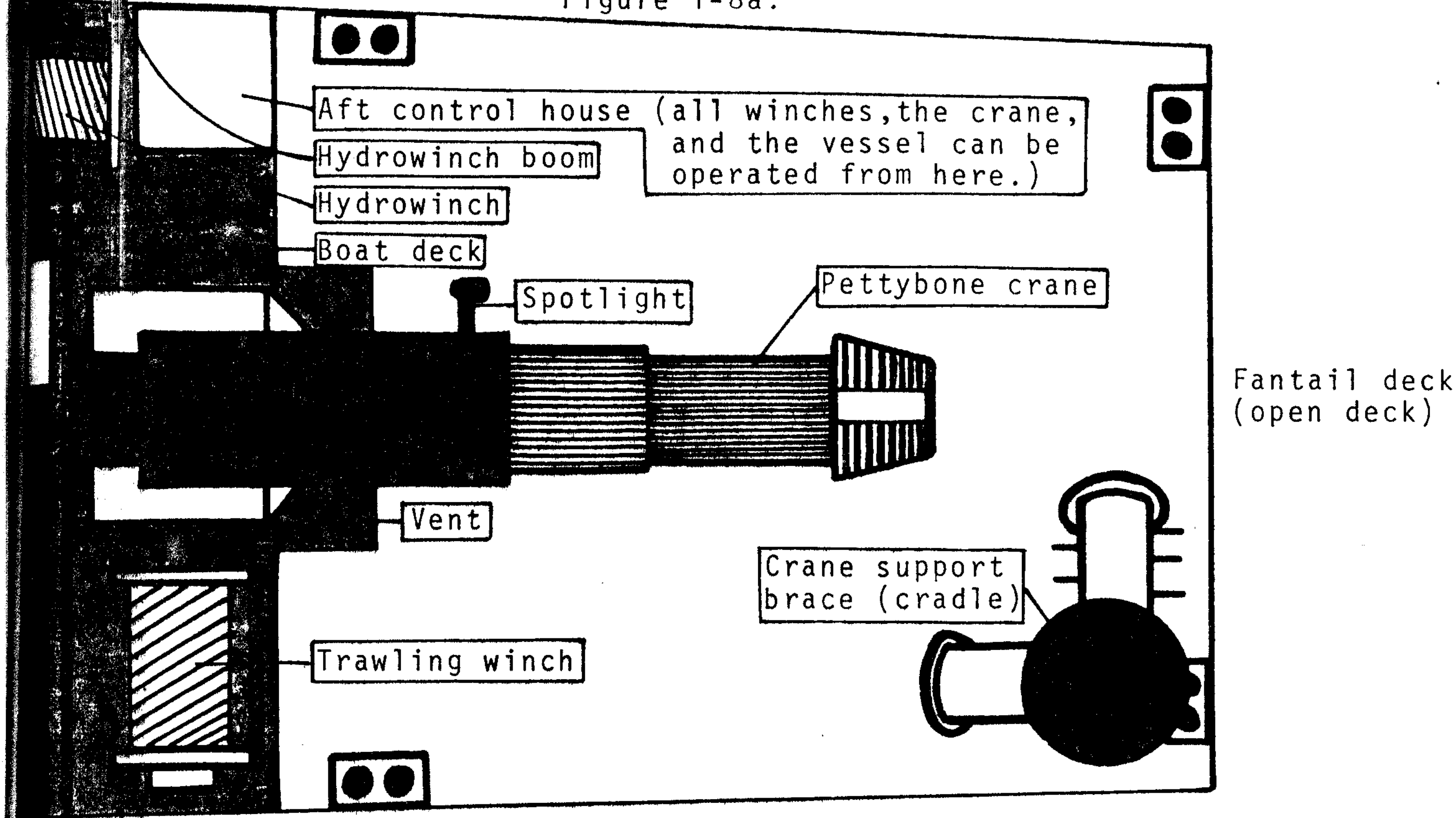
Freshwater is stored in the freshwater tanks which are also situated beneath the lower deck (see Figure 1-9) next to the fuel tanks.

The R/V Wecoma has eleven (11) tanks altogether between the lower deck and hull bottom (see Figure 1-9).Four (4) tanks are for fuel along with one (1) day tank.Four (4) tanks are for ballast.One (1) tank is for freshwater and the last tank is a holding tank for ship's wastes.

Above deck,the R/V Wecoma is equipped with three (3) winches and a petty-bone crane that are used to assist in scientific experiments such as the Profiling Current Meter (PCM) experiment and Conductivity,Temperature,and Depth (CTD) experiment.These experiments require the submersion of scientific equipment far beneath the sea surface. Through the use of these winches,the instruments involved can be lowered and retrieved. Each of the winches have a seperate function.One is a deep-sea winch,another a trawling winch,and the last a hydrowinch.All the winches are electric.The reason for the winches being electric is to eliminate noise and interference with the scientific experiments. The winches and petty-bone crane are all situated aft by the fantail (see Figure 1-8a and Figure 1-8b) where the experiments take place.

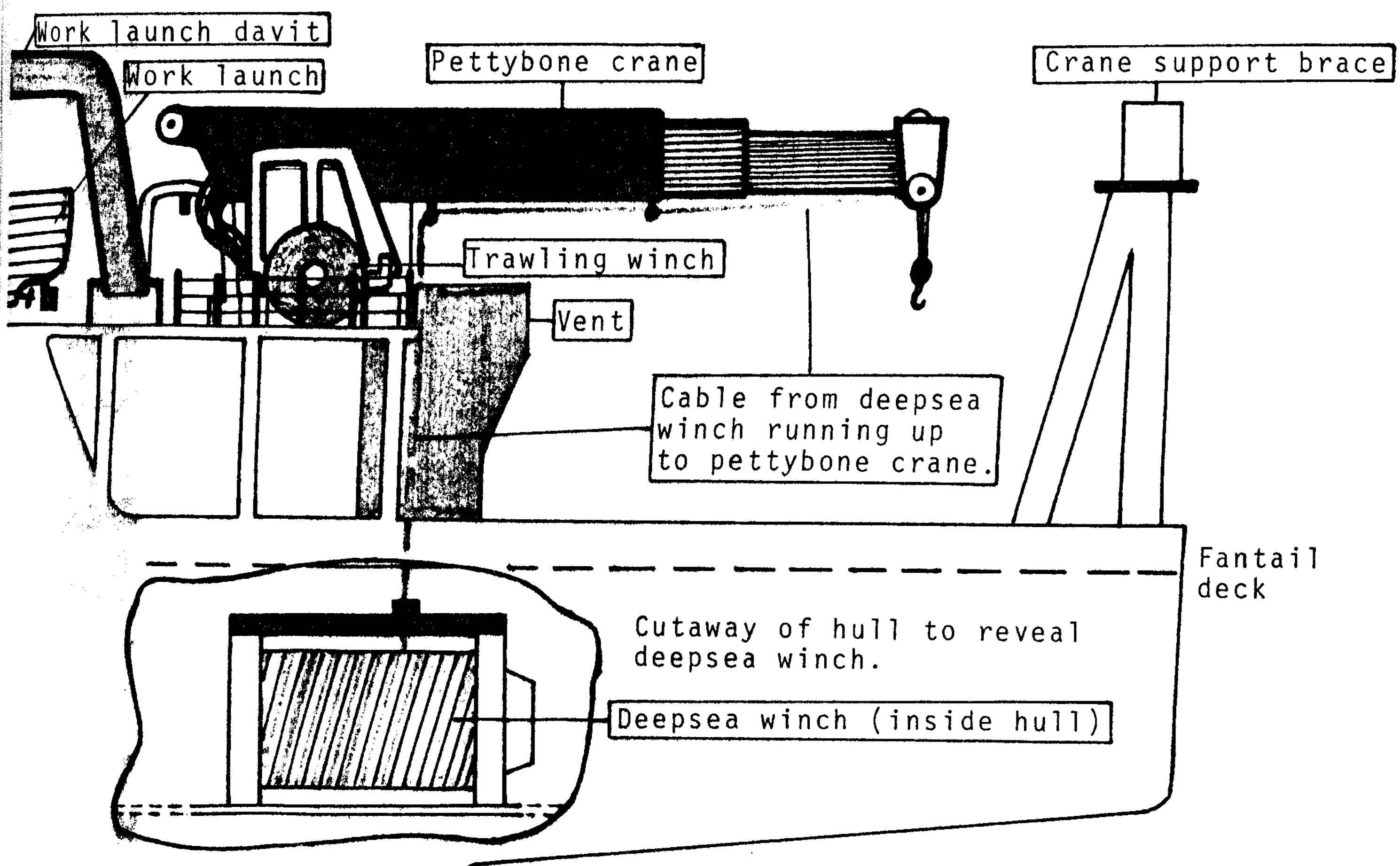
The hydrowinch and trawling winch are out on the boat deck above the fantail.The deep-sea winch is below the fantail deck with the cable running up and out through the petty-bone crane.The deep-sea winch is equipped with 30,000 feet of 1/2 inch braided wire cable.The trawling winch is equipped with 20,000 feet of 3/8 wire wound conductor cable.The hydrowinch is equipped with 30,000 feet of 3/16 wire cable.With the winches well stocked with cable,the R/V Wecoma can operate almost everywhere in every ocean. The only exceptions being some of the deeper trenches such as the Philippine Trench, Mariana Trench,etc.

Figure 1-8a.



The deepsea winch is located below the fantail deck. The cable from the deepsea winch is run up through the crane.

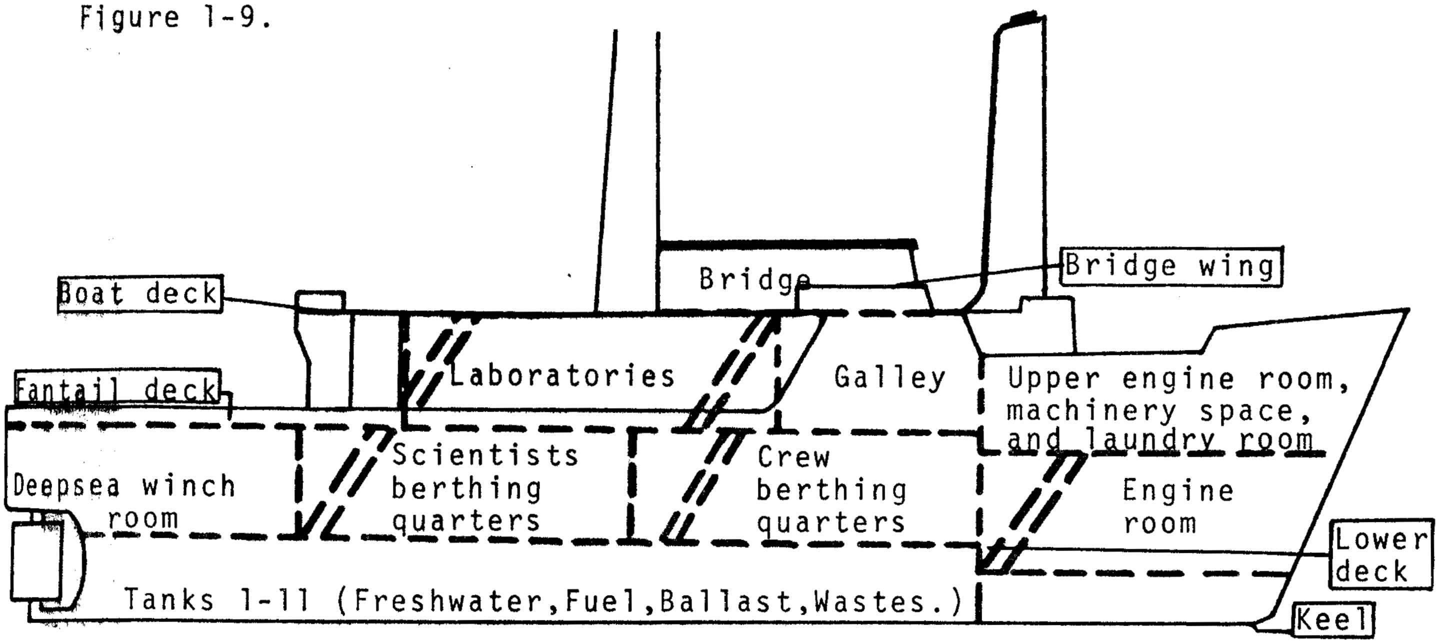
Figure 1-8b.



The R/V Wecoma is equipped with a work launch,that is easily launched,to be used in scientific experiments that occur in shallow waters near atolls,reefs,shoals,and islands,etc.The work launch can also act as the second vessel in experiments requiring two vessels.

Going back inside,sleeping quarters for both the crew and scientists is located aft of the engine room on the lower deck (see Figure 1-9).The forward lower deck is the engine room.The lower deck midships is the sleeping quarters and the stern section is the deep-sea winch locker.The crew have the staterooms closest to the engine room and the scientists have the staterooms furthest from the engine room.The berthing arrangements are structured like this so as to provide maximum quiet and comfort for the scientists.

Figure 1-9.



Each stateroom consists of two bunks (except one which has four),a closed desk,a settee,two closets,a sink,and a combined sundry rack and mirror.All the rooms are styled in simulated mahogany finish with appropiate lighting and have air conditioning. In addition,there are antenna jacks in each room so radios and televisions can be plugged in and have excellent reception.The onboard movies can be seen individually in the rooms if so desired by simply connecting a television to the antenna jack. The living arrangements,which can accommodate up to sixteen (16) scientists in addition to the ship's crew,have been made as comfortable and pleasant as the vessel's size permits.

Continuing upward,the main deck (see Figure 1-9 and Figure 1-10) runs the length of the vessel from the bow to the fantail.The fantail deck is actually a continuation of the main deck.It is on the main deck that the laboratories are situated.

The R/V Wecoma is equipped with two (2) laboratories for scientific instruments and experiments.One is a wet lab for experiments incorporating water or other liquids in their operation.The other is the dry lab where electronic equipment such as computers,recorders,plotters,and printers are kept.Much of the data processing is done in this laboratory.These two laboratories together occupy 1,000 square feet of space. The laboratories have direct access to the fantail deck where many of the experiments take place.The fantail deck has over 1,200 square feet of space which allows plenty of room for experiments.Being structured as such,the R/V Wecoma is well suited for handling research work.

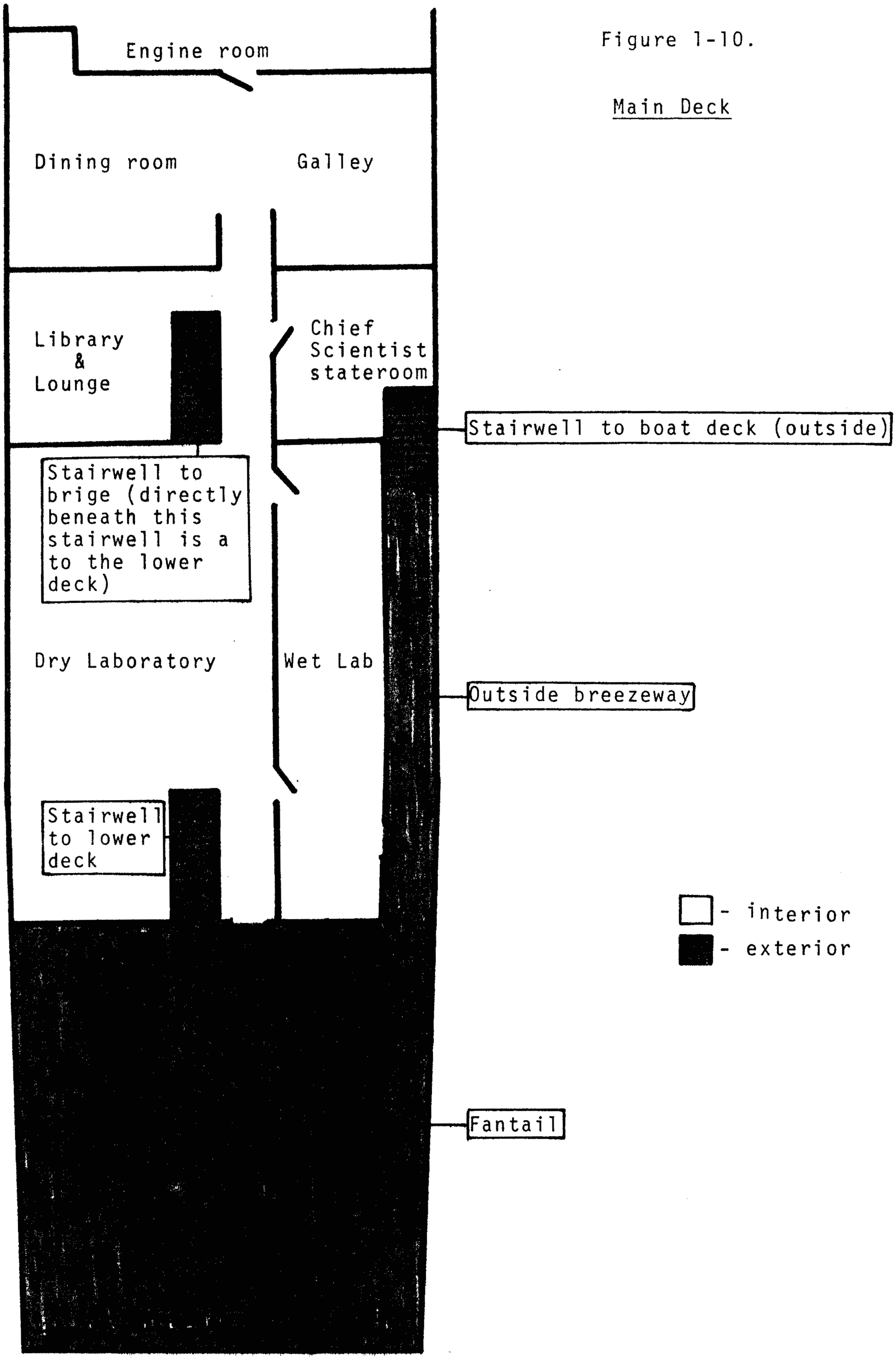
Going forward and back inside,the galley and combined library/lounge are forward of the laboratories on the main deck.The library is stocked (over 1,000 volumes) with novels on almost any subject.The library is equipped with a television that plays over 200 video games - in addition to normal operation.The television also provides daily showings of top rated films that have been provided as entertainment.(Examples are:Saturday Night Fever,Heaven Can Wait,Murder On The Orient Express,Looking For Mr. Goodbar,etc.)There is also an international radio that receives worldwide with excellent reception.The library is styled as a den with nautical decor and finishings and has comfortable furniture.

The galley is well supplied with cooking utensils and modern cooking equipment. Meals are served three times a day with a choice of entrees.A person is permitted to eat as he or she chooses.The galley is also equipped with a television that can show the movies or have a different television show on,from the one in the library.The galley operates like a cafeteria but on a smaller scale and with better food.

Above the main deck is the boat deck (see Figure 1-1,Figure 1-2,Figure 1-9,and

Figure 1-10.

Main Deck



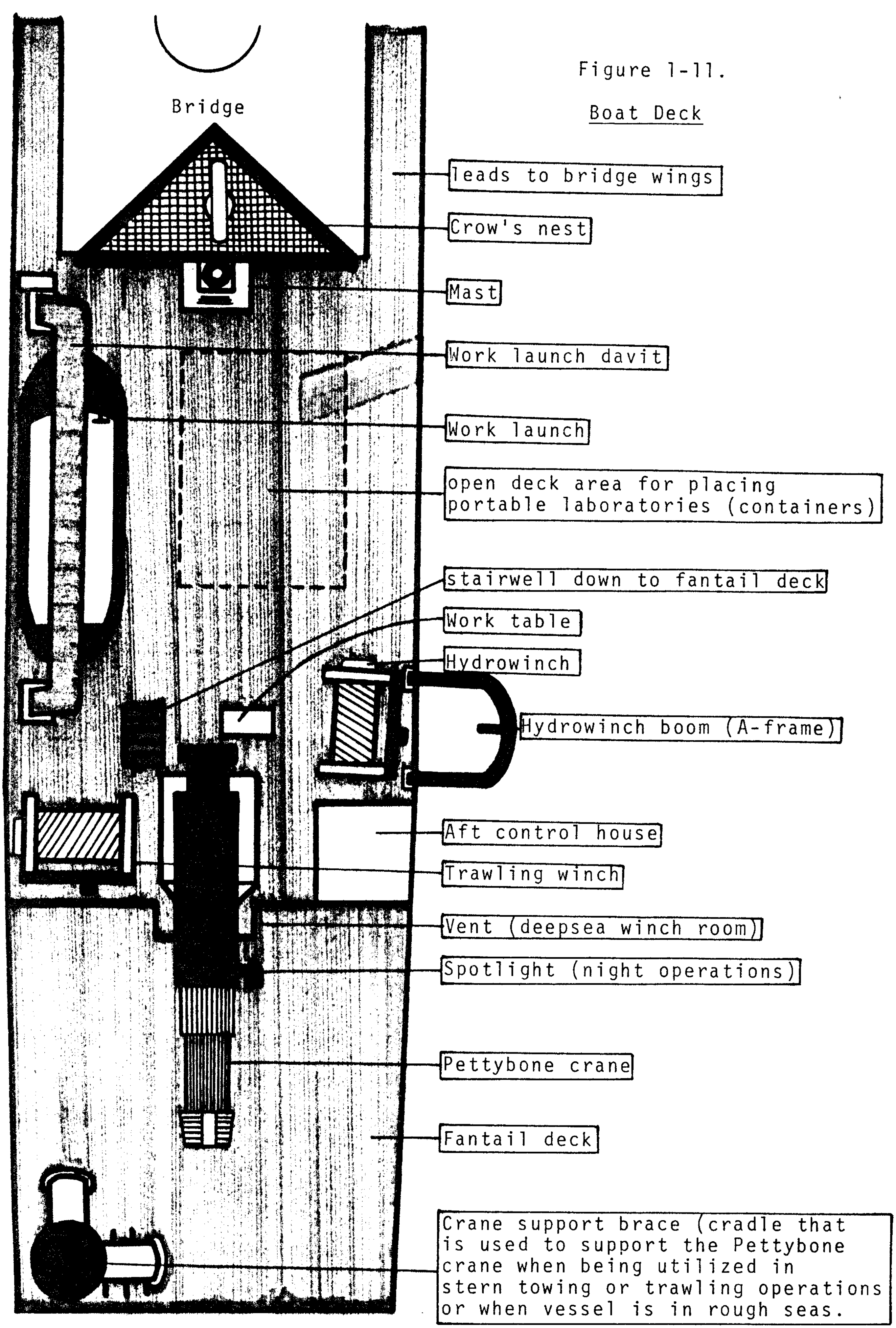


Figure 1-11.
Boat Deck
Bridge
leads to bridge wings
Crow's nest
Mast
Work launch davit
Work launch
open deck area for placing portable laboratories (containers)
stairwell down to fantail deck
Work table
Hydrowinch
Hydrowinch boom (A-frame)
Aft control house
Trawling winch
Vent (deepsea winch room)
Spotlight (night operations)
Pettybone crane
Fantail deck
Crane support brace (cradle that is used to support the Pettybone crane when being utilized in stern towing or trawling operations or when vessel is in rough seas.

Figure 1-11) where the petty-bone crane,hydrowinch,trawling winch,and work launch are located.The boat deck,in addition,contains the liferafts (the R/V Wecoma has no lifeboats).Behind the bridge and forward of the winch area,the boat deck has available space.This spare space is utilized for portable laboratories that come in the shape of containers.These containers are similar or identical to the containers shipped by containerships and trucks.The R/V Wecoma carried two (2) containers for the NORPAX/FGGE expedition.This arrangement for portable laboratories makes it very easy for universities and research institutions to send their scientific equipment in one big bulk shipment to the R/V Wecoma and have it protected while onboard.Also,if the expedition is crowded,the portable laboratories can serve as instant scientific facilities.The portable laboratories are equipped with lighting and electrical fixtures that readily connect to the ship's electrical system.Both portable laboratories on the NORPAX/FGGE expedition belonged to Scripps Institution of Oceanography.

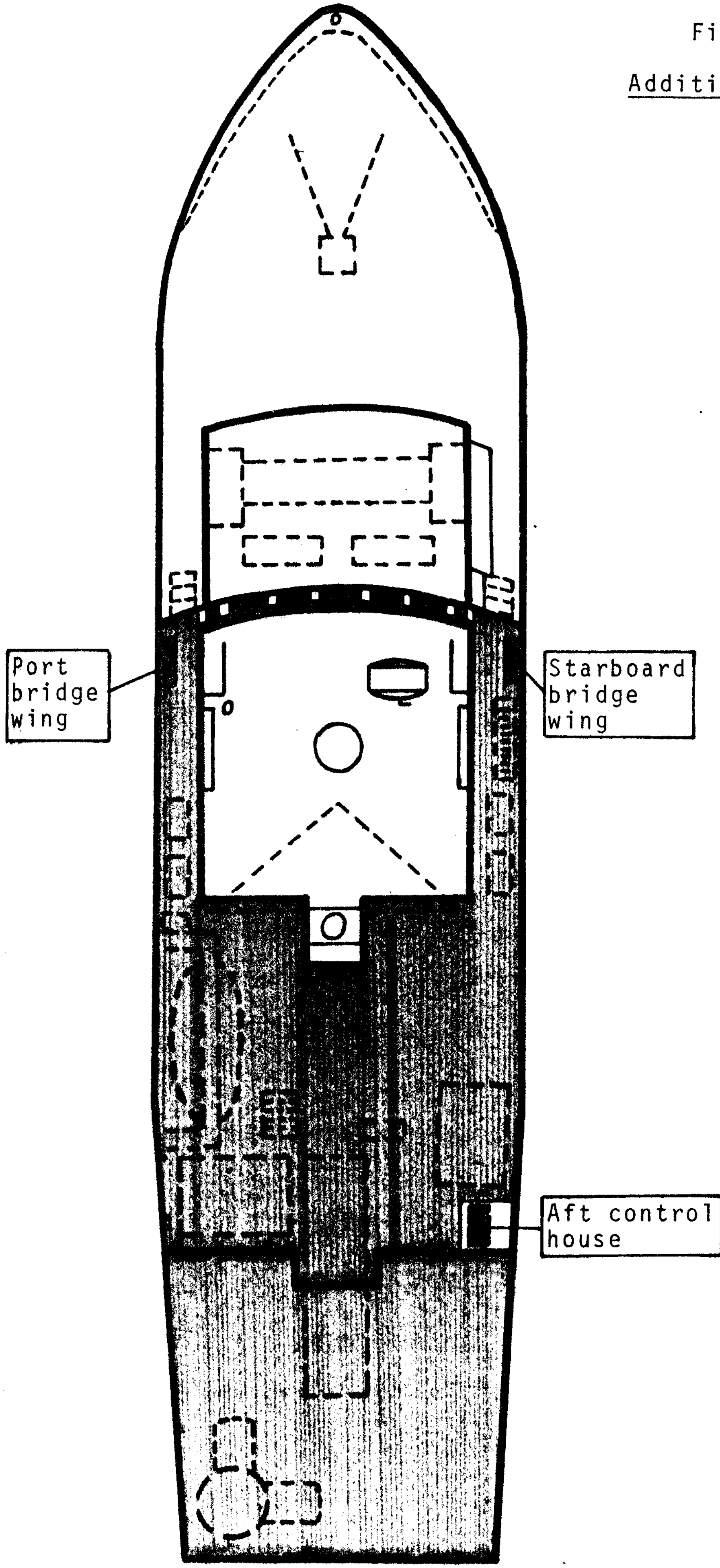
Slightly raised above the boat deck and forward of the mast is the bridge and bridge wings (see Figure 1-1,Figure 1-2,Figure 1-9,and Figure 1-11).The bridge is the control center of the vessel.The engine throttle for regulating speed and pitch control for adjusting propulsion are both found on the bridge.However the engine can not be started from the bridge.The engine is air-started by the engineer in the engine room upon receiving the command from the bridge via the telegraph.

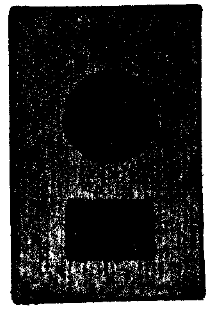
Steering is done by the automatic pilot.There is no steering wheel on the R/V Wecoma.In manual operation,the steering is done by a joystick that directs the Kort nozzle which in turn directs the ship's heading.The steering system is operated by a standard Sperry gyro that is based on true degrees.Should the gyro ever fail,the vessel is equipped with a magnetic compass.

The R/V Wecoma can also be operated from three (3) additional control centers located (see Figure 1-12 on following page) on the bridge wings and after boat deck.All control centers can steer the vessel,move the vessel,and operate the bow thruster.Experiments often require delicate manuevering of the vessel which can only be done by visual overseeing of the situation.These control centers are also valuable in docking

Figure 1-12.

Additional Vessel Control Centers





Symbol for control centers

operations.In cases like this,the vessel is controlled from one of these additional control centers where the ship's officer on watch has a better view of the situation and can manuever the vessel accordingly.

The R/V Wecoma is equipped with two (2) Decca radars that operate on ten megahertz (10 MHz).The one radar is a navigational radar utilized in harbors and other similar geographical areas.This radar has its heading set to the bow of the ship.

The other radar is a plotting radar used out on the open ocean to assist in navigation.This radar has its heading set to true north by a gyro incorporated in the unit. This radar has absolute stabilization which makes it very precise.

For determining the vessel's position (latitude and longitude),the R/V Wecoma depends upon a satellite.The satellite will plot the vessel's exact position to within 150 feet of the actual point on the Earth.This is extremely crucial because scientific experiments depend on accurate positioning in order to know exactly where they are to be conducted or have been conducted.

The satellite is a Navy satellite that broadcasts it's position above the Earth in relation to the Earth's parallel and meridian coordinates.The satellite will inform the vessel as to when it will come over the horizon (in relation to the vessel's position on the Earth),the elevation above the Earth,and the specific tangent angle in relation to the vessel at that moment.The tangent angle is the angle between the satellite's position above the Earth and the tangent line between the satellite and vessel as the satellite comes over the horizon.It should be remembered that at this very instant,the tangent line between the satellite and vessel will touch the spherical arc of the Earth.The spherical arc is the curvature of the Earth,

On the R/V Wecoma's bridge there is a receiving unit called the navigator which will take the satellite's information and process it.The navigator is a computer that is informed,upon departure from port,of the vessel's intended course,intended speed, and position (at time of departure).The navigator then combines the above pieces of information with the received satellite information and calculates the vessel's position on the Earth.Without explaining the actual mathimatical process involved,the navigator employs sherical trigonometry based upon the Doppler shift of radio waves to make its calculations.As stated before,this instument is accurate to within 150 feet of the actual latitude and longitude coordinates.

As a backup to the navigator,the R/V Wecoma has an Omega Loran C receiver that can plot position by radio waves.The Loran C receiver incorporates a micro-processor that filters out "noise" such as skywaves.This insturment is fairly accurate but does not compare to the navigator.

To determine ship's speed,the radar (only good when you have reference points such as land),navigator,and Loran C are used.In addition,the vessel is equipped with a Sperry speed log.The speed log is a sonar that determines speed from the Doppler shift of reflected radio waves off the water particles as the vessel moves through the water.

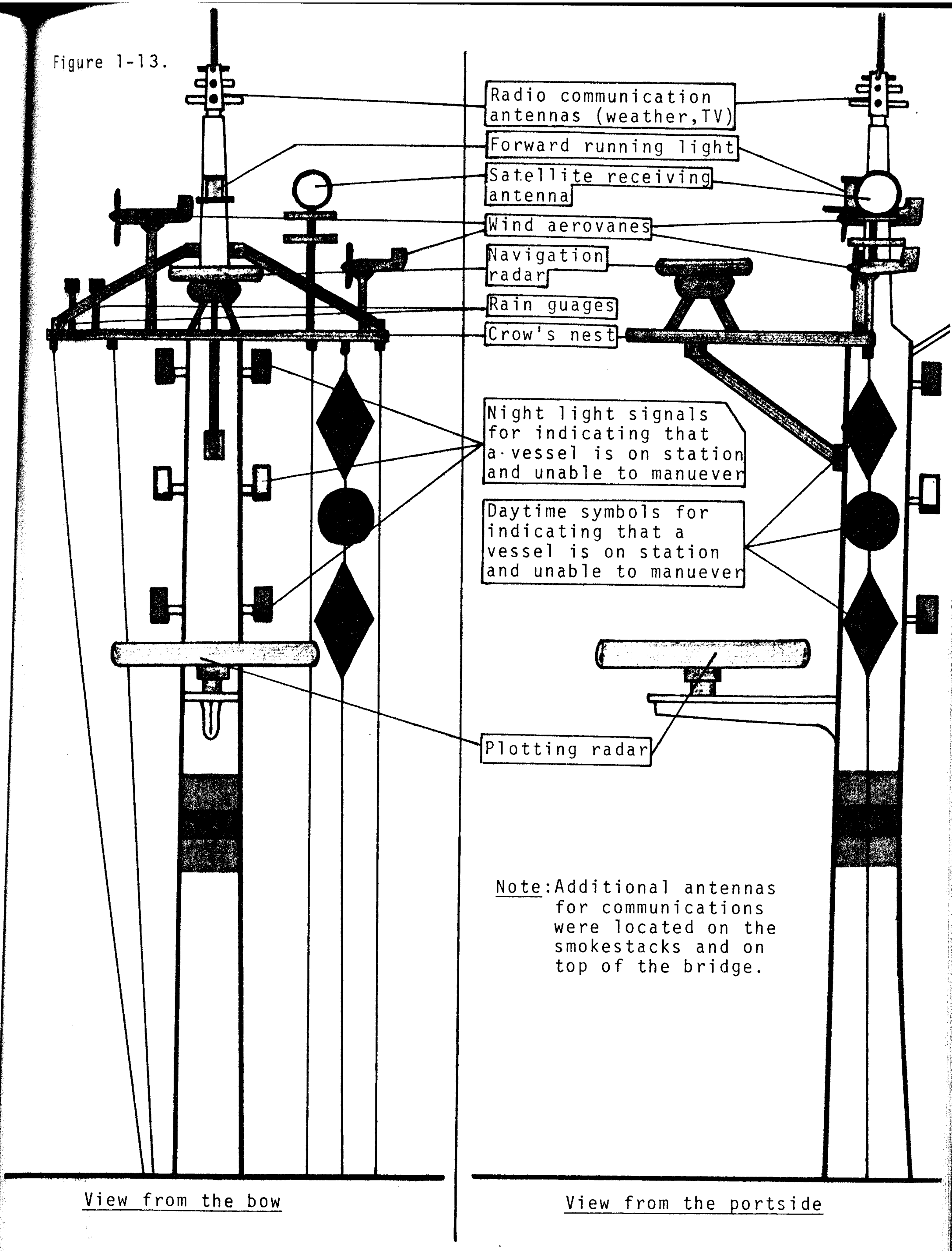
Water depth is determined by either two (2) precision depth recorders (PDR's) or a fathometer.The precision depth recorders (PDR's) will be defined in the next chapter. The fathometer is a sonar that detects the sea floor via radio waves that are sent out and reflected back.The fathometer will convert the reflected radio waves and their information into a graphic display that can be read.The fathometer,however,is only effective for depths of 4,800 feet or less.

For receiving weather information,which is important to both the operation of the vessel and scientific experiments,the R/V Wecoma is equipped with a Great SPR-4 weather receiver and an Alden Marine Fex graphic weather receiver.The graphic weather receiver is a unique weather receiver that electronically reproduces an actual weather map based upon the weather transmission.See Appendix A for actual map.

Communication with land is provided by a single side band (SSB) and a Lorain radio decoder.The Lorain radio decoder allows the vessel to be in contact with its homebase via an encoded radio transmission that only the homebase receiver can decipher.

The SSB is a standard radio transmitter and receiver that contacts a land based marine receiving station.Radio communication with land is needed for notifying respective universities and research institutions of the progress of scientific experiments. Also,if certain equipment is needed or replacement parts,the radio provides immediate

Figure 1-13.


Radio communication antennas (weather,TV)
Forward running light
Satellite receiving antenna
Wind aerovanes
Navigation radar
Rain guages
Crow's nest
Night light signals for indicating that a·vessel is on station and unable to manuever
Daytime symbols for indicating that a vessel is on station and unable to manuever
Plotting radar
Note: Additional antennas for communications were located on the smokestacks and on top of the bridge.
View from the bow
View from the portside

contact with the appropiate party.

Local weather information is an important aspect of the research operation and the R/V Wecoma is therefore equipped with certain weather instruments.

The vessel has two (2) aerovanes that indicate wind speed and direction.These instruments are electronically operated with digital recorders in the drylab.This allows the scientists the convenience of simply looking at the digital recorder for the wind information.

The R/V Wecoma has three (3) rain guages for indicating precipitation.One is positioned on the boat deck along the railing.The others are located up in the mast so as to maintain minimum interference with data gathering.Tubes run down the mast to the boat deck so that they can be read.

Surface sea temperature is given by a thermometer in the engine room hull plate and a thermosalinograph.

Conventional thermometers and barometers give the air temperature and barometric pressure.In addition,some of the scientific instruments used in the experiments give these readings along with sea surface temperature.

Much of the navigation equipment,communication equipment,and weather equipment that has been mentioned is located in the mast (see Figure 1-13).By having the equipment located there,the equipment is able to function with the least amount of interference.

Manning of the R/V Wecoma is as follows:one (1) master and two (2) mates with ocean licenses,three (3) engineers,four (4) deckhands,one (1) combined electronics technician and radio operator,one (1) cook,and a messman.By having this complement of crew,the R/V Wecoma is in compliance with U.S.Coast Guard regulations and needed manning of a research vessel.

The R/V Wecoma leases for $5,000.00 per day.Much of the needed funds is provided by the National Science Foundation (NSF),National Oceanographic and Atmospheric Administration (NOAA),universities such as Oregon State University (OSU) and the University of Hawaii (UH),and research institutions such as Scripps Institution of Oceanography (SIO).The source of funds will of course vary depending on who is conducting scientific experiments with the R/V Wecoma.

The R/V Wecoma has now been analyzed from the keel up to the mast with directed attention towards the structural design and equipment that makes the vessel well suited for the roll of research ship.The combination of structural characteristics such as the cutter lines,low profile superstructure,high sea-breaking bow,stabilizing fins,large fantail,and appropiate interior layout as well as equipment characteristics such as the quiet low vibrational engine,bow thruster,Kort nozzle steering mechanism,winches,petty-bone crane,navigational instruments,and weather instruments make the R/V Wecoma an ideal research vessel.The R/V Wecoma's applicability to scientific research projects is well defined and is undoubtably one of the reasons for being selected to participate in the NORPAX/FGGE expedition.

II

Scientific Data Collection Techniques.

[As used on the R/V Wecoma in conjunction with the NORPAX/FGGE expedition legs 12-15 between Hawaii and Tahiti (1980).]

The techniques of scientific data collection varied with each of the experiments being conducted.The methods of obtaining the raw data,extracting the desired data,and retaining it all depended on which experiment was being performed.Therefore it is essential to look at each experiment respectively in order to observe the method used. All instumentation as well as modes of operation will be examined in this format.

There were eight (8) experiments being conducted on the NORPAX/FGGE expeditions. The first experiment was the Conductivity,Temperature,and Depth (CTD) experiment.The second experiment was the Expendable Bathythermograph (XBT).The third experiment was the Profiling Current Meter (PCM) experiment.The fourth experiment was also a PCM but it utilized a computer and sonar for deriving current profiles.This experiment was basically a comparison of the computer/sonar PCM against the other PCM which utilized aanderaas for deriving current profiles.The fifth experiment was a surface current study utilizing drift buoys that were set adrift and then tracked by satellite.The sixth experiment was a solar radiation experiment of the incoming sunlight.The seventh experiment was the Atmospheric Gas Sampling (AGS) analysis of the quantities of gases in the atmosphere.The last experiment was a dissolved nutrient study of dissolved elements in the water.Each experiment will now be examined individually.

The CTD experiment was a chemical analysis of the ocean waters down to a depth of 1,015 meters.The CTD did an analysis of the temperature,dissolved oxygen level,conductivity,pressure,and salinity of the water column from the surface down to 1,015 meters. The temperature was obtained by the use of thermometers.The dissolved oxygen content was obtained by an oxygen sensor.The conductivity was derived from a conductivity cell, and pressure was obtained by the use of a strain-guage pressure sensor.Salinity was then calculated mathimatically from combining the above data.All of these data guages were attached to a metal cage unit,along with a battery pack for power,and lead weights for preventing drift.

The cage unit is called a fish.Figure 2-1 below depicts the fish with the data guages attached.The elongated containers on the upper part of the fish are called Niskin bottles.Collectively,the fish with the attached guages is called the CTD unit.As the CTD

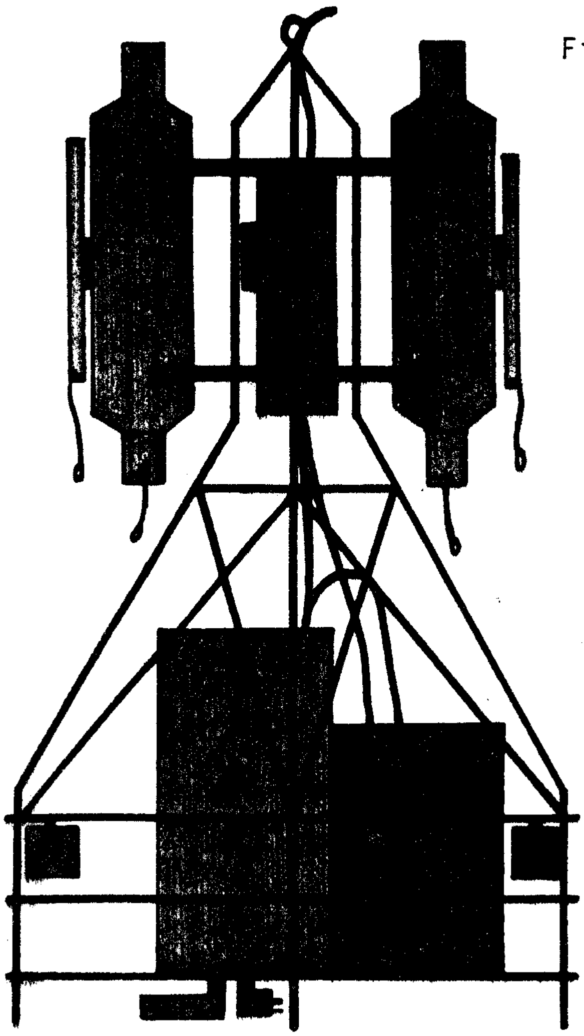
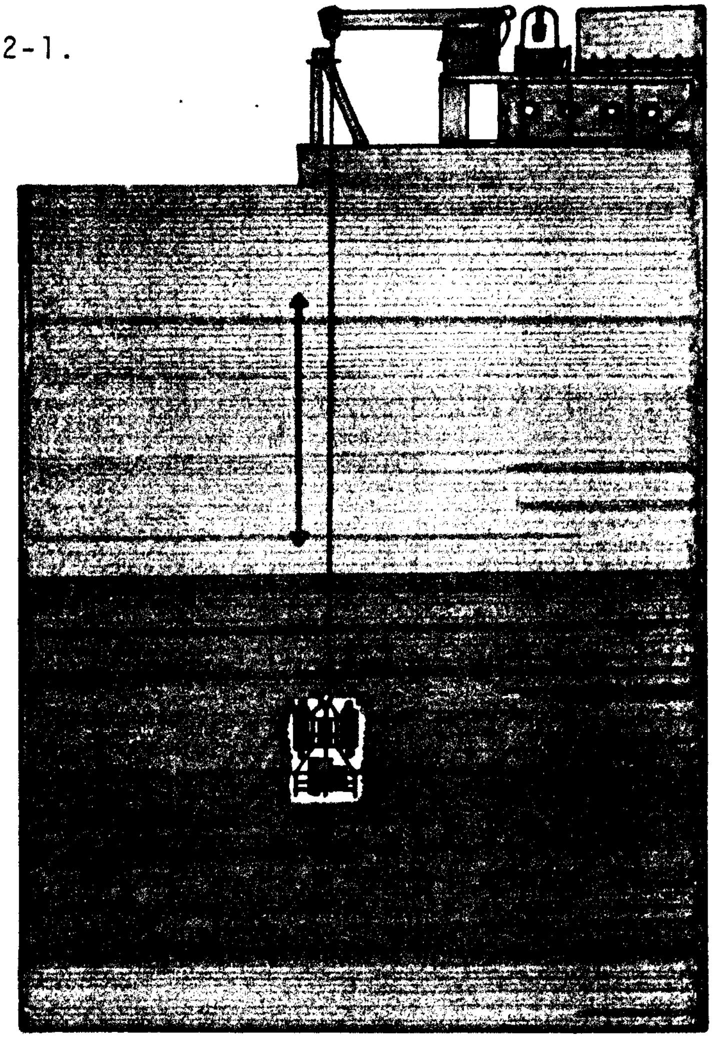


Figure 2-1.



unit descended in the water column,the data was obtained instantly and received simultaneously on board the R/V Wecoma.The data was transmitted via an electric cable that was spliced into the wire line holding the CTD unit.The wire line used for lowering and hauling up the CTD unit was the 3/8 inch wire cable on the trawling winch.The petty-bone crane was used to lift it in and out of the water.

The receiving unit,which was in the drylab,consisted of a CTD digital readout terminal,an oscilloscope,and a computer.The CTD digital readout terminal would visually display the readings by light emmiting diodes.This allowed for instant observation of the data so that the scientists could see how the experiment was progressing.

The oscilloscope interpreted the data as a wave.The oscilloscope was used to monitor the progress of the experiment as it took place.The purpose of the oscilloscope was to watch for "noise" which is interference caused by external forces.These external forces could be mechanical,electrical,physical,or biological.

The computer was used for extracting and retaining the data.As the raw data was received by the computer,the computer would sort the information and send it to the recording instruments to be recorded.The recording instruments consisted of a teletype printer,a plotter,and a tape recorder.

The teletype printer would print the data the same way a typewriter would.The plotter would record the data in the form of graphs and the tape recorder would record the data as "clicks" on the tape.

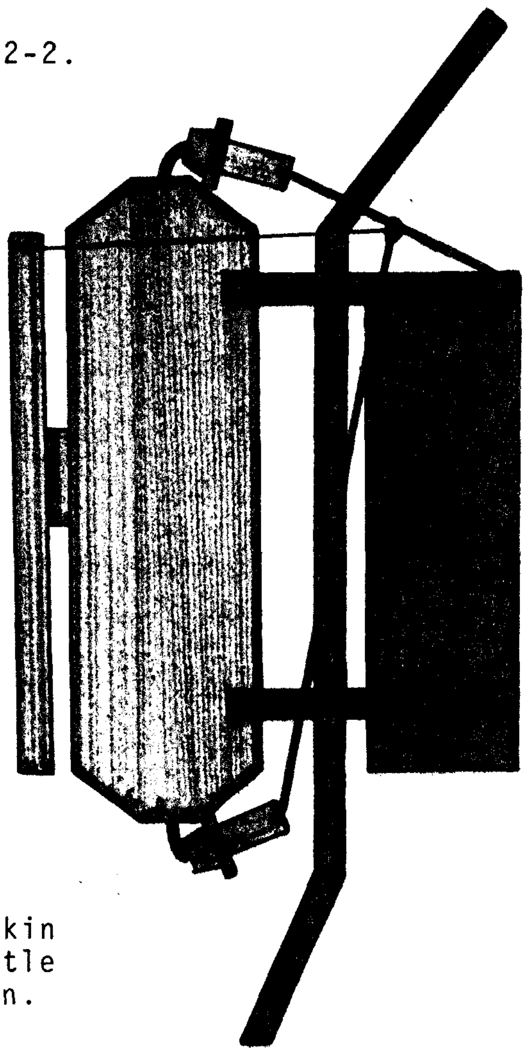
The entire CTD experiment was conducted by the scientists from the laboratory via electronics.Through the use of a telephone,the scientists were in contact with the crane and winch operator who would lower and raise the CTD unit as directed.The scientists would also use the telephone to contact the bridge which was responsible for maintaining the vessel on station (in position).

In addition to the above role,the CTD unit also took water samples at different preselected depths.The purpose of the water samples was to have extra data that could be examined onboard to verify the proper functioning of the CTD unit.Through the use of onboard testing equipment,the scientists could check the water samples and then compare them to the electronically recorded data.These water samples were also used in the nutrient experiment.For obtaining the water samples,two (2) special instruments were used.

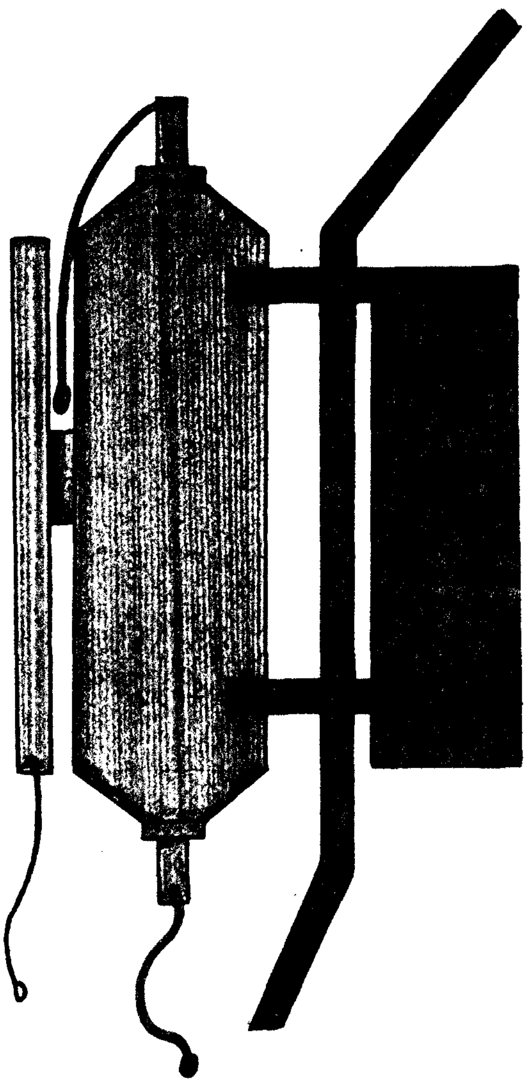
The one instrument was the Inversion thermometer.The Inversion thermometer is a thermometer that is held in an inverted (upside down) position until the desired depth for taking a water sample is reached.The Inversion thermometer is fastened to the outside of a Niskin bottle;and at the same time that the Niskin bottle takes the water sample,the Inversion thermometer takes the temperature.The Inversion thermometer,upon receiving the signal to take the water sample will flip around to its upright position. The signal is an electrical impulse that triggers a mechanical diaphram to release the Inversion thermometer and Niskin bottle.As the Inversion thermometer flips around,the mercury in the thermometer will flow into the recording tube and record the temperature. It should be noted that prior to this moment,the mercury was stored in a storage tube that is connected to the recording tube.However upon being uprighted,a small valve opens letting the mercury flow out into the recording tube.When the correct temperature has been recorded,the mercury stops flowing and the valve prevents further mercury flow.The amount of mercury in the recording tube can not change so the reading is therefore constant.This is how the temperature of the water sample is recorded.

The other instrument used was the Niskin bottle.A Niskin bottle (see Figure 2-2) is a hollow cylinder with a plug at each end.The Niskin bottle is lowered vertically (on the CTD unit) with the plugs held open so as to allow water to pass through it.When the

Figure 2-2.



Niskin bottle open.



Niskin bottle closed.

desired depth is reached,the plugs will snap back into place sealing the Niskin bottle with the water sample inside.At the same moment that this occurred,the Inversion thermometer will have flipped around and recorded the temperature of the water being sampled.The plugs are held open by a nylon line that is connected to a small mechanical diaphram which releases the nylon lanyard upon receipt of a electrical signal.The diaphram is a device that will open when an electrical impulse is sent to it.It is basically a latch that is in a closed position but opens when charged with electrical current.The electrical impulse is sent down the wire cable from the laboratory.The Niskin bottle is rigged like this so as to let the scientists choose when the sampling is to be done.If temperature is not important,the Niskin bottles are used without the Inversion thermometers.After the Niskin bottle and Inversion thermometers are brought up,along with the CTD unit,the temperature is recorded in a logbook and the water samples sent through a salynometer for salinity analysis.After the salinity analysis,oxygen analyses are done.

The salynometer is an electrical device that determines salinity and then visually displays the data results by light emitting diodes.The data readout is then recorded in a logbook for later reference.

The oxygen analysis is a chemical test where chemicals are added to the water sample.As the chemicals are added,reactions take place which are visually observed by the scientists.The resulting reactions indicate the level of dissolved oxygen.These observations are logged along with the salinity results and temperature readings for later references.

All the data reults from both the CTD and the water samples are sent back to Scripps Institution of Oceanography for further testing and studies.Based upon these studies,theories will be formulated to explain the structure of seawater.

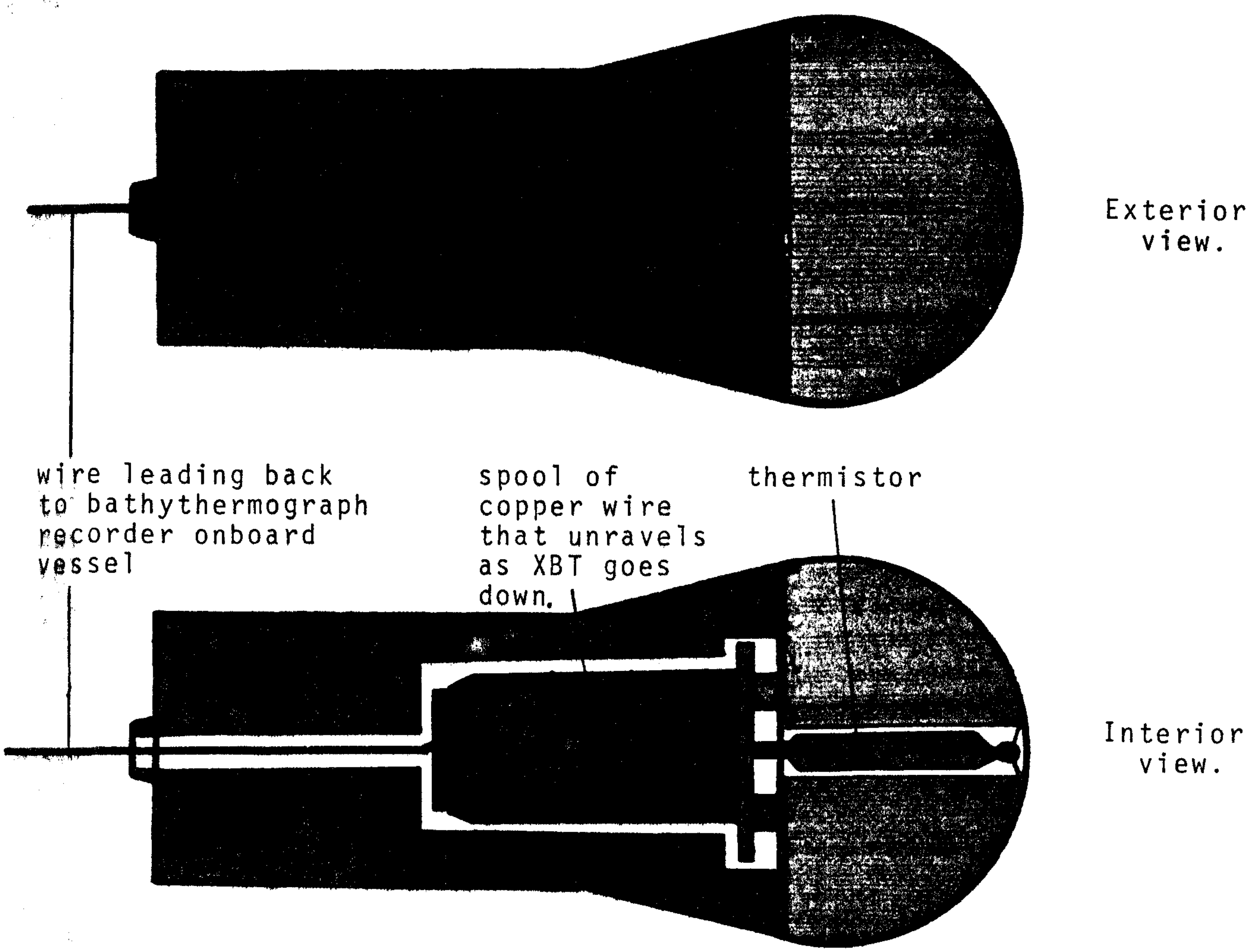
The location of all sampling is given at the end of the chapter.

The second major experiment was the Expendable Bathythermograph experiment.The Expendable Bathythermograph,hereafter known as the XBT,is a temperature profile study of the oceans down to a depth of 450 meters.The XBT has different depth ranges depending on how it is used.The XBT experiment served two functions.The first function of the XBT was to gather data which is then analyzed for purposes of understanding the topography of the sea surface.By analysis of the temperature structure of the ocean,the topography of the sea surface is derived.

The second function of the XBT was to supply information to the U.S. Navy on the temperature structure of the ocean water masses.The U.S. Navy uses the data to conduct submarine warfare.It has been detemined that water masses of different temperatures can hide submarines due to their different termal structures which blanket the submarine from surface detecting devices.

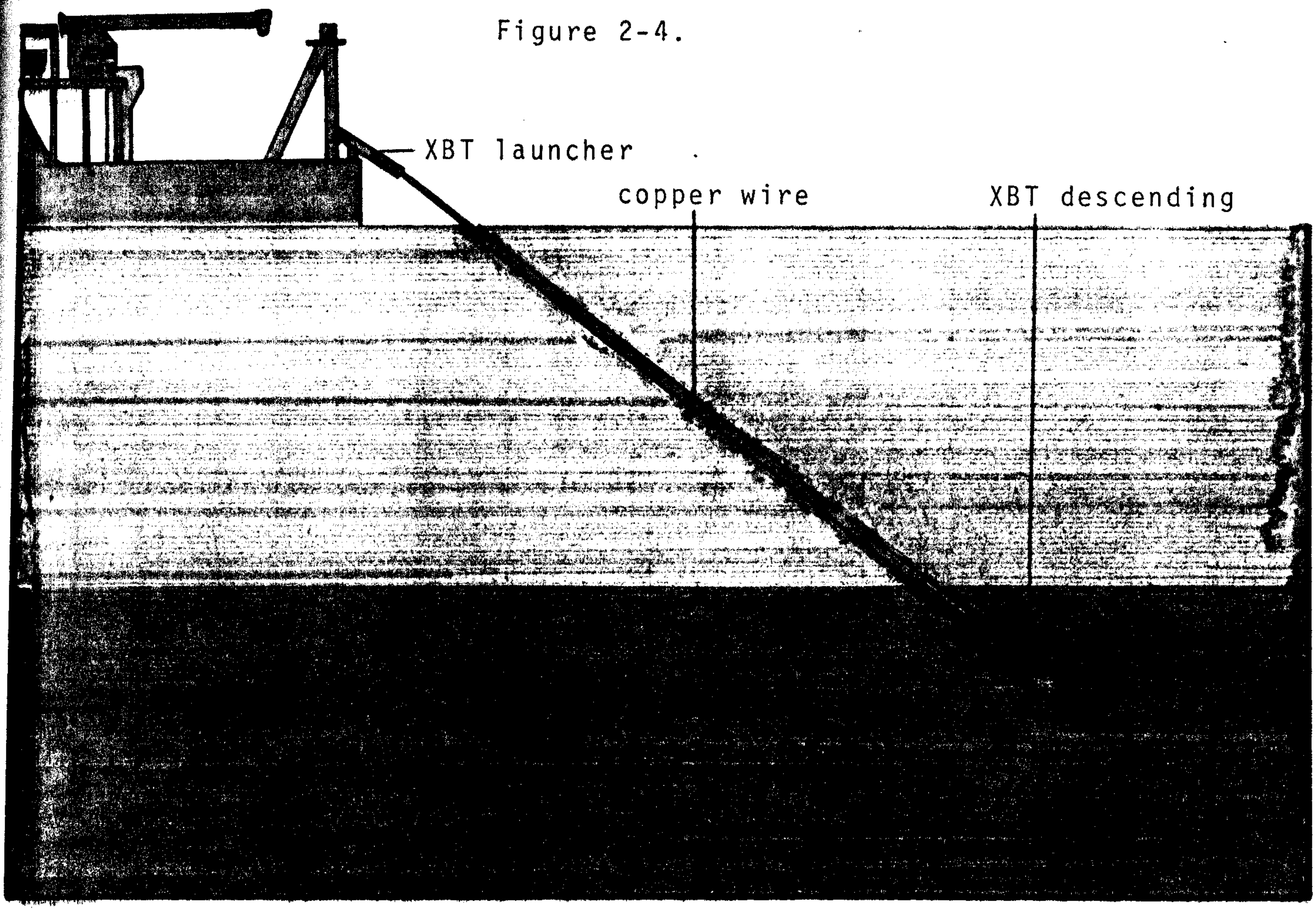
The XBT experiment involves two instruments;the expenable bathythermograh,and the thermograph recorder.As shown below in Figure 2-3,the expendable bathythermograph is a torpedo-shaped unit with a thermister in the nose and a spool of fine two-conductor copper wire that unwinds as the XBT descends through the water column.Once the XBT is

Figure 2-3.



launched,it freefalls at a constant rate and the termister records the temperature.The temperature data is sent back to the thermograph recorder via the copper wire.Figure 2-4 depicts the XBT descendind the water column.At 450 meters,the spool of wire has run out and the XBT breaks free.The XBT will continue to the bottom never to be seen again.The depth range of the XBT is determined by the length of wire on the spool.If one desires to record a temperature profile of greater depth,an XBT with more wire is utilized.

Figure 2-4.



The XBT provides a continuous readout of temperature as long as the electrical connection is maintained.The wire,that is being unwound as the XBT descends,is connected to the thermograph recorder which is graphically recording the temperature data on paper. The thermograph recorder is simply an electrical receiver that converts the electrically transmitted temperature data into a graphic image.The X-axis of the graph is temperature and the Y-axis of the graph is depth.The graph is a simple inverse relationship of decreasing temperature with increasing depth.

The whole process of doing the XBT requires one minute.The graphs are sent to the

Navy immediately as a radio transmission.The graphs themselves are sent to the University of Hawaii for topographic studies.

The Navy must have the data within six hours following the dropping of an XBT.This is so they can produce maps of the temperature structure of the water mass quickly which can then be forwarded to the submarines.The submarines then utilze the information for finding hiding spots in the water mass.After six hours the XBT data is invalid since the temperature structure of the water mass may no longer be exsistant in the same way as it was.The hiding spot that might have exsisted six hours ago may not be there anymore.It should be noted that the XBT data is still valid for the topographic studies.However the small changes that do occur are crucial in determining hiding spots.

The XBT was a reliable instrument that functioned well though there were a few cases of questionable readings.Many of the questionable readings were simply due to failure of the XBT and were therefore easily corrected by dropping another XBT.

The Profiling Current Meter (PCM) experiment was a current study of the currents in the equatorial Pacific down to a depth of 500 meters.The PCM experiment required the use of seven instruments.The required instruments were an aanderaa,a profiling current meter hull (PCMH),a precision depth recorder (PDR),two tape recorders,an aanderaa translator, and a stripchart recorder.

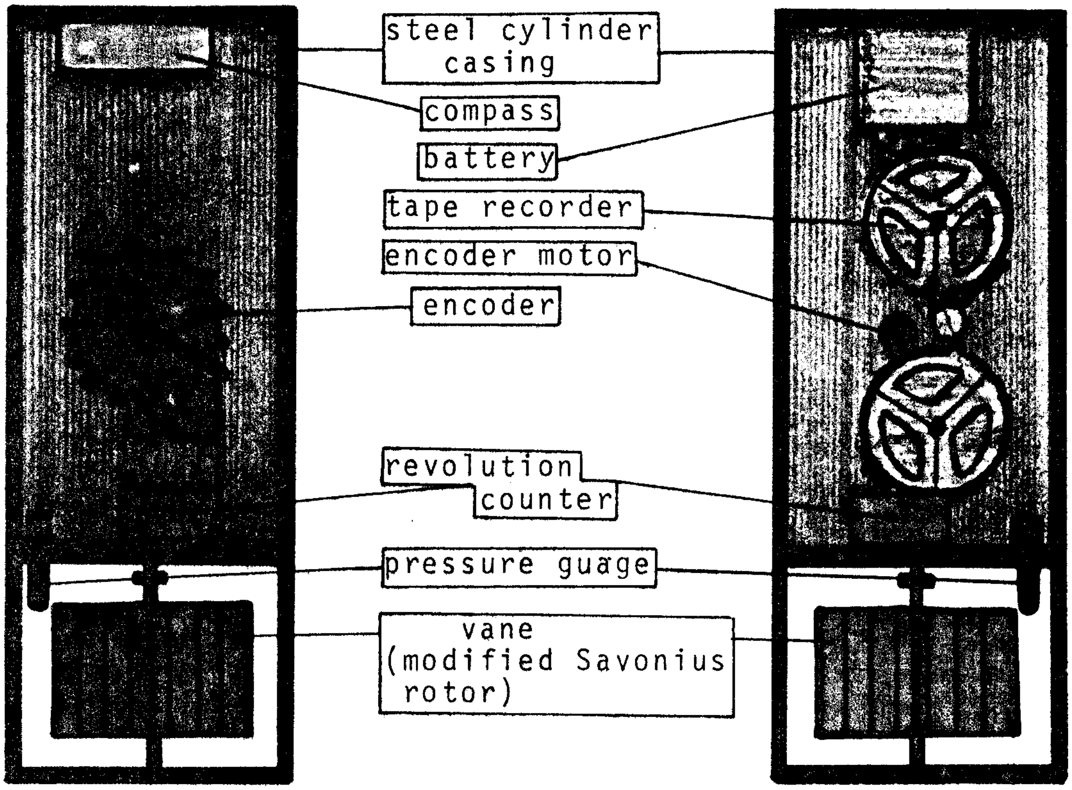
The aaderaa is the data collecting unit which is sent down to collect the data.The aanderaa is a sophisticated electronic unit that records the velocity of the current and the direction of the current as it descends the water column.The aanderaa,as depicted in Figure 2-5,is essentially comprised of seven parts that make it function.

The battery supplies the power.The vane,which is a modified Savonius rotor,revolves on its axis due to the current flowing by it.The revolution counter calculates the velocity of the current.The revolution counter is connected to the vane by a shaft that serves as the axis of the vane.The calculated velocity is then sent to the encoder.

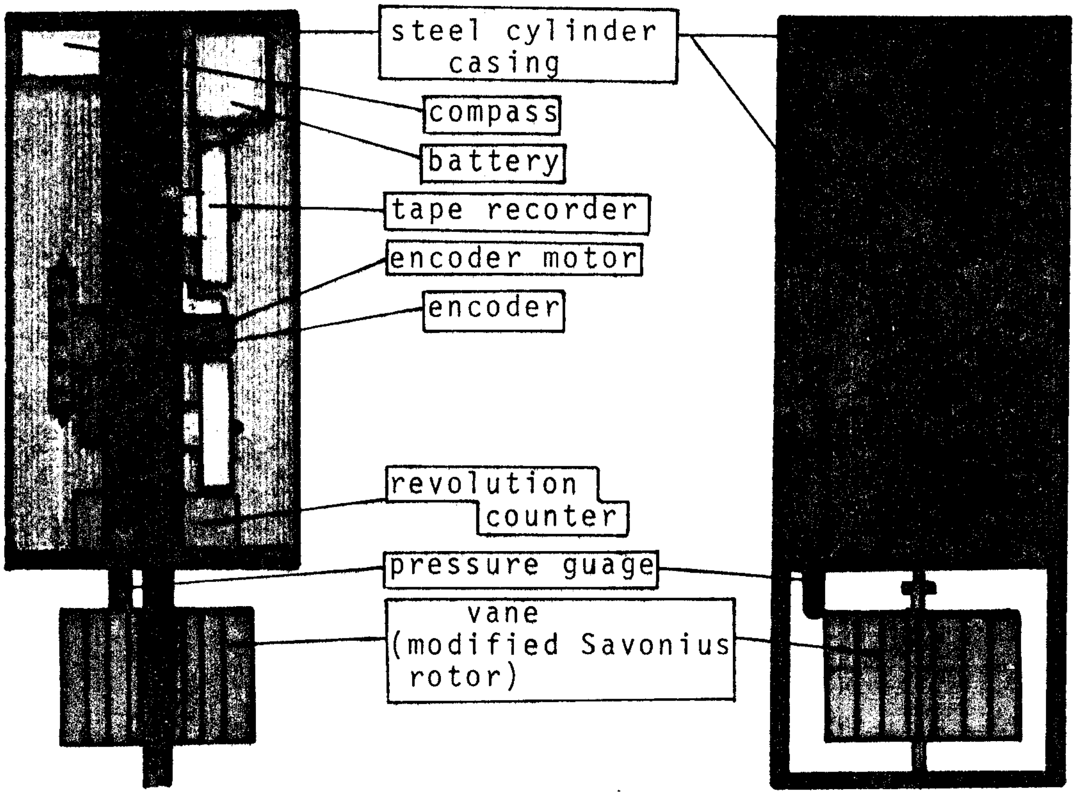
The pressure guage records the pressure which is then translated to depth and sent to the encoder for encoding.

The compass,which is an electronic compass,records the direction of the current based

Figure 2-5.



The above diagrams depict the insides of the aanderaa as it would appear when viewed from both sides.The below left diagram provides a view of both sides of the circuit board.The below right diagram depicts the aanderaa as it would appear when encased in it's cylinder case.In other words,its outside appearance.



on the position of the unit in relation to North,East,West,and South.The position of the aanderaa is determined by the PCMH which will line up into the current.This information is then sent to the encoder to be encoded along with the other information.

The encoder is a device that converts the different pieces of data into a message that can then be put on tape.Once the data has been encoded,the data is put on tape.

The aanderaa recorded data every thirty seconds as that was the chosen sampling time. In other words,there would be a new readout of velocity,depth,and direction every thirty seconds which was put on tape.The aanderaa operated for seventy-two (72) hours consecutively as that was the lifetime of the battery.This does not mean that the unit was being used for seventy-two (72) hours consecutively but that it was left running for that period of time.After seventy-two (72) hours,a new battery was needed,as well as a new tape.The tapes used in the aanderaa were only capable of seventy-two (72) hours continuous operation.

The PCMH is the unit used for carrying the aanderaa down through the water column.As shown in Figure 2-6,the PCMH is constructed of plastic pipe with negatively buoyant flotation balls inside of it.The purpose of this unit is to bring the aanderaa down at a slow prescribed rate of descent.This permits the aanderaa to collect the data properly.In other words,get accurate readings.Figure 2-7 depicts the PCMH with the aanderaa going

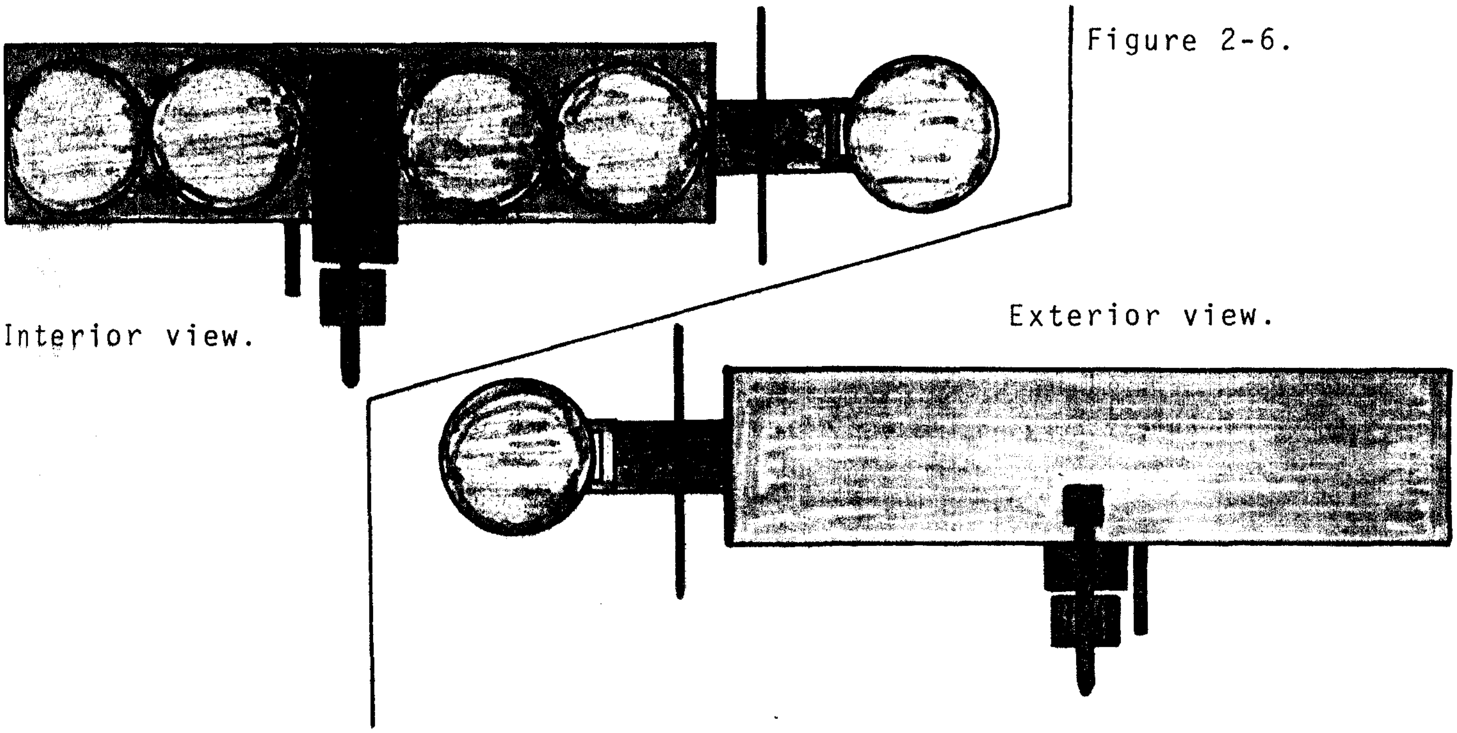
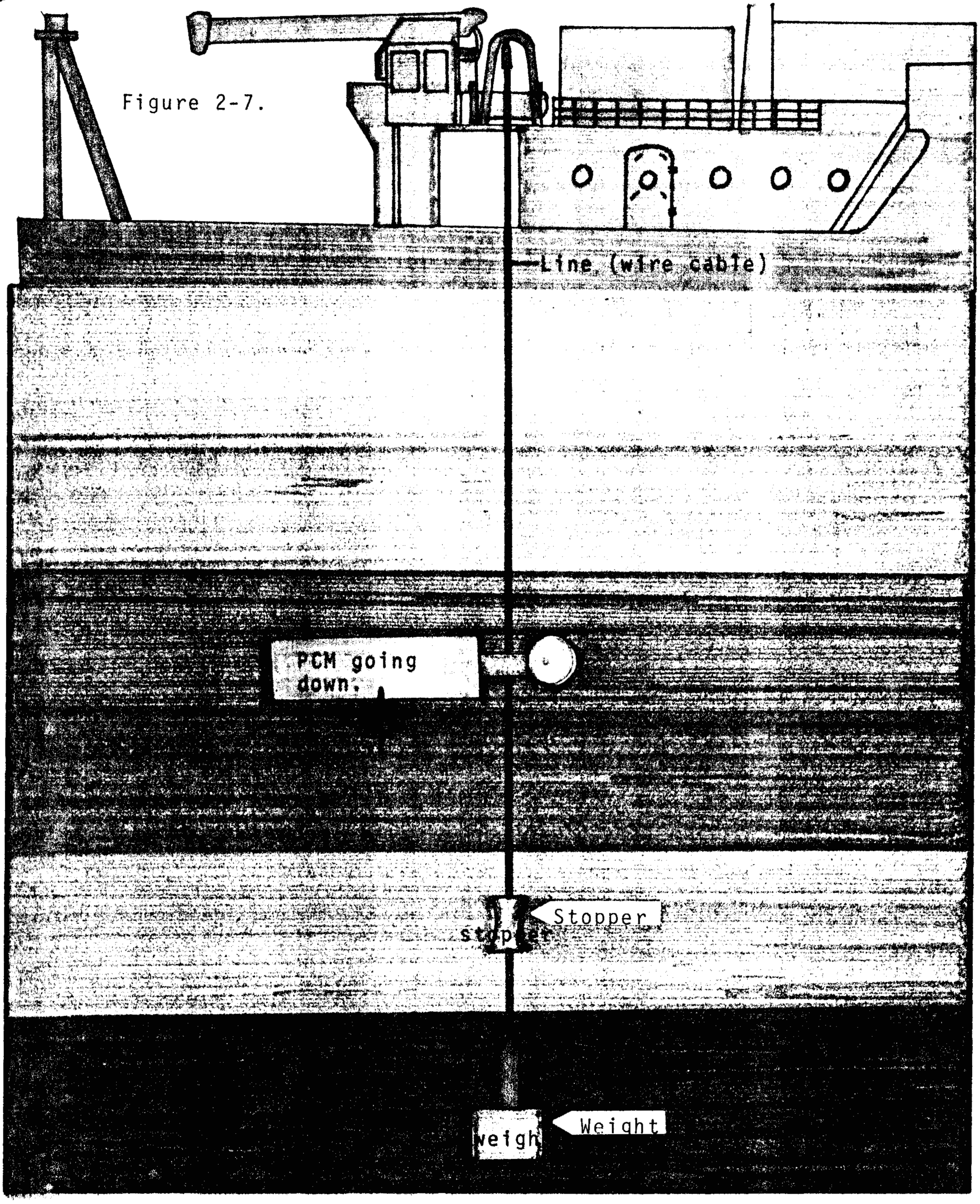


Figure 2-6.

Interior view.

Exterior view.

Figure 2-7.



down.The PCMH hold the aanderaa in a vertical position with the vane facing downward.The PCMH is attached to a thin wire cable that has a weight on the end of it so as to help maintain a vertical wire and proper descent of the unit.A stopper near the end of the line will stop the unit from further descent.The stopper is meant to keep the unit away from the weight which could destroy the unit.The weight was a lead weight of approximately 300 pounds.

The entire rig was fastened to the vessel by a winch which put down the line and hauled up the line.The line with the weight would be sent down first to 500 meters.The PCMH with the aanderaa would then be attached to the line at the surface and allowed to descend slowly to the stopper.Upon reaching the stopper the whole thing would be hauled up.Altogether the PCM required approximately one hour and fifteen minutes.Most of the time was used for descent of the PCM.Five minutes was needed to put the line out and the unit attached;and eight minutes was needed to haul up the unit,disconnect it,and stow the equipment.

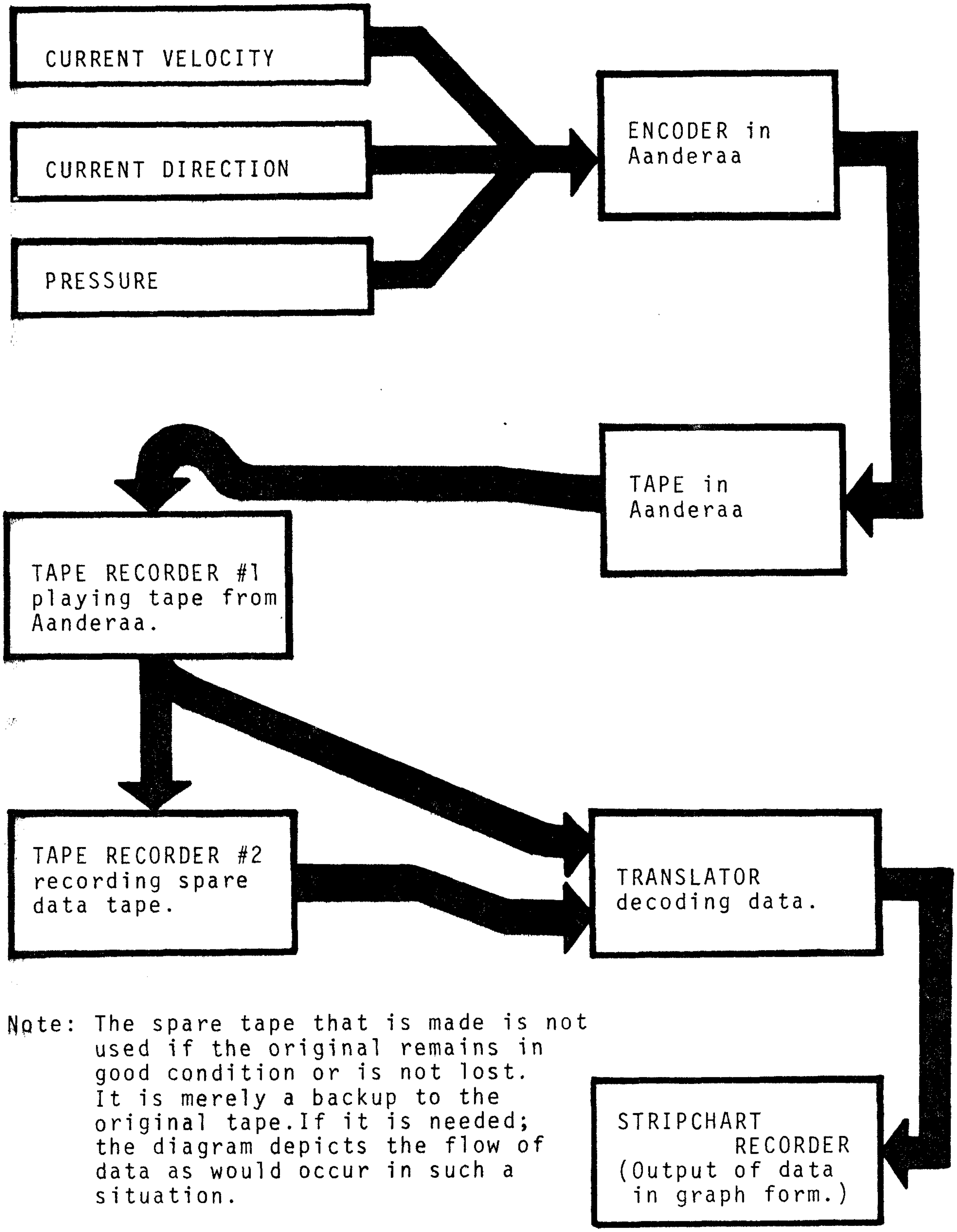
The precision depth recorder (PDR) is used to observe the descent of the PCM.The PDR is a fathometer that tracks the PCM as it descends by sonar.The PDR graphically records the descent of the PCM on paper.The weight is also marked on the graph since the sonar is capable of "seeing" it.When the PCM no longer shows any descent and it is very close to the weight,the scientists in the laboratory know that the PCM has completed its profile. The whole thing may then be hauled up.The PDR,PCMH,and aanderaa are used everyday as the different stations came up.

The other four instruments are used every seventy-two (72) hours when a full tape of data has been recorded.When a full tape of data is obtained,it is then removed from the aanderaa and put on one of the tape recorders.The other tape recorder is rigged to record off the first one so that an extra data tape can be obtained.This is done in case the first one (original) is damaged,lost,or erased.

The aanderaa translator is a decoder that will convert the encoded data tapes into data that the stripchart recorder can understand and graphically represent.The translator basically decodes the data that was encoded by the aanderaa.The decoded data is then represented as graphs by the stripchart recorder.To facilitate comprehension of how the data flows through the different instruments,Figure 2-8 on the following page depicts the flow of data from when it is initially received to to when it is graphically recorded.

The graph produced by the stripchart recorder is the visual profile of the currents. The accumulation of many such current profiles over an area give scientists the infor-

Figure 2-8.



Note: The spare tape that is made is not used if the original remains in good condition or is not lost. It is merely a backup to the original tape.If it is needed; the diagram depicts the flow of data as would occur in such a situation.

mation needed to propose their theories on ocean circulation.Both the tapes and graphs are taken back to the University of Hawaii for analysis and study.The locations of the current profiles that were conducted is noted later in the chapter.

The second PCM experiment being conducted involved the use of sonar for determining the current structure of the water column.

The sonar/computer profiling current meter (SCPCM) experiment was an acoustic method of deriving current profiles.The SCPCM utilized a sonar,computer,and tape recorder.

The sonar is the data collecting unit.The sonar sends out high frequency sound waves oriented towards different directions of the water column.These sound waves then reflect off of the particulate matter in the water. At the same time that the sound waves hit the particulate matter and are reflected,the particulate matter will shift due to the current.The movement of the particulate matter will cause a change in the reflected frequency of the sound wave.It is the change in frequency of the sound wave that will be measured by the sonar and computer.The resulting change of frequency is measured according to a principle known as the Doppler shift.The change of frequency is then translated into current velocity by the computer.

The direction of the current is determined from combining the measurements of the different directed sound waves.

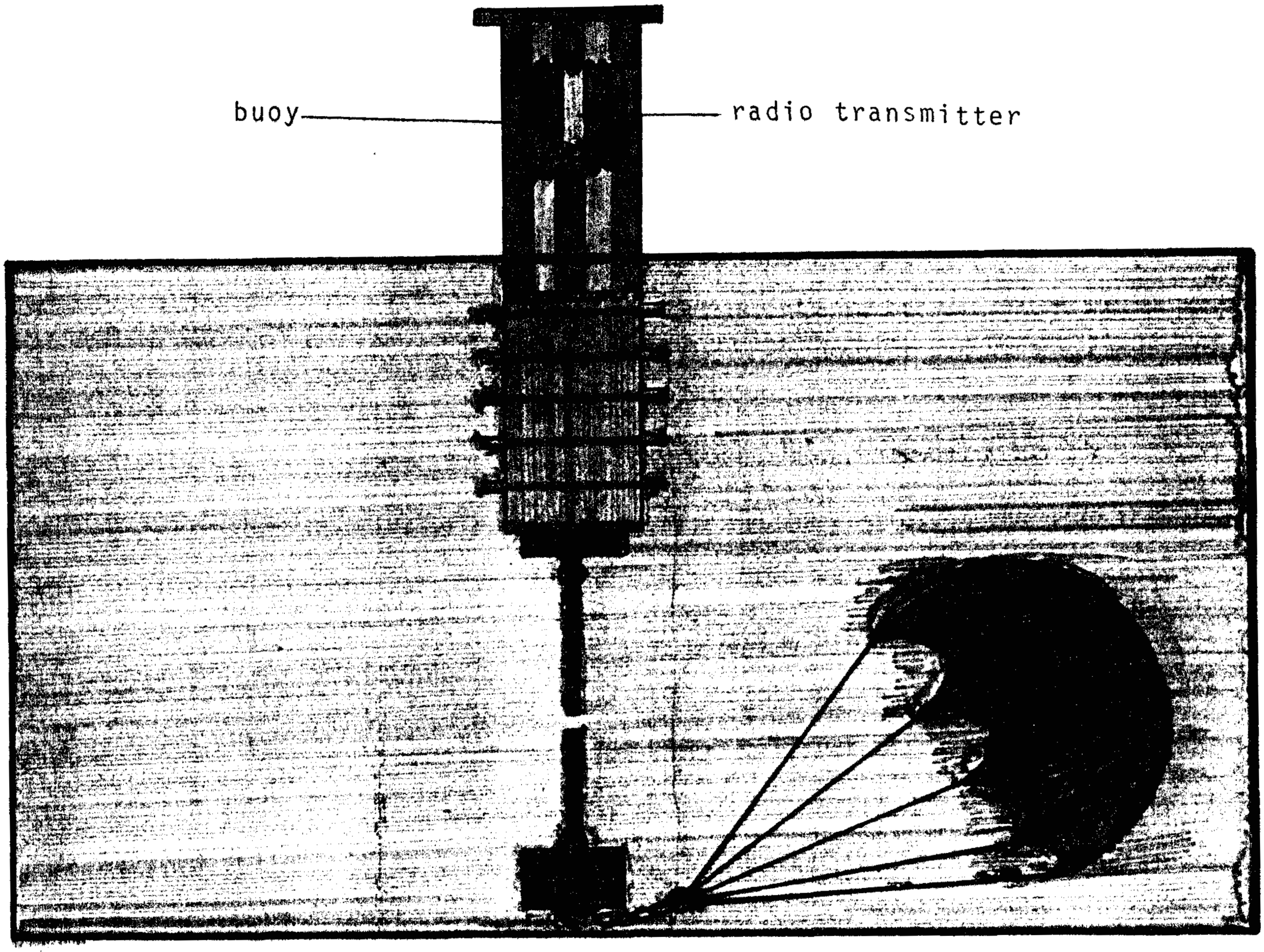
The computer takes all the data and transforms it into a current profile that is then graphically represented on the video screen of the computer.The computer,in addition,converts all the data into information which is then stored on tape.The tape recorder records all the data put out from the computer.

The SCPCM continuously gathers data as the vessel moves along.The data obtained will be updated every 5½ minutes as a new set of data is received.Since the sonar is directly under the vessel,the current profile is a profile of the waters directly under the vessel.The SCPCM is effective as a current profiler down to a depth of approximately 200 meters.Below that,the SCPCM is useless.The SCPCM is proving very useful as a PCM such that it may be used from aircraft or satellites in the future.The National Aeronautics Space Administration are conducting tests on the feasibility of such an idea.

The data collected by the SCPCM is sent back to Scripps Institution of Oceanography for further studies and analysis.

The fifth experiment was a study of the surface currents of the equatorial Pacific Ocean.There was no data collecting done by the vessel or scientists on board.The only function of the vessel and scientists was to deploy the buoys at certain predetermined locations in the equatorial Pacific.These buoys were then tracked by satellite and their movements monitored by the satellite receiving station.The buoys themselves,as depicted in Figure 2-9,are equipped with a radio transmitter that broadcasts a signal every fifty-five (55) seconds.The radio is powered by power cells that last for two years.The radio

Figure 2-9.



signal is set at a certain frequency that only the satellite "hears".As the buoy drifts along,the satellite traces it.Since the author was only on the later legs of the experiment,the author can only vouch for what was deployed on those later legs.The locations of deployment of the buoys is given later in the chapter.The number of buoys deployed while the author was on board was thirty.

The solar radiation experiment was conducted continuously throughout the duration of the expedition.The solar radiation experiment required only two instruments.The one instrument was the solar cell that detected the solar radiation and amount of radiation.The other instrument was the solargraph recorder which records the information.The solargraph recorder is simply a device that converts the data into a graphic representation of solar intensity.The solar cell was situated up in the mast where it could record data without interference.The solargraph recorder was located in the laboratory.This experiment ran by itself with no assistance from the scientists.

The atmospheric gas sampling (AGS) experiment was an experiment to determine the amounts of certain gases in the atmosphere.The gases being sampled were Methane,Carbon dioxide,and Ammonia.The instruments utilized were a gas chromatograph,plotter,and tape recorder.This experiment was a continous ongoing experiment on all northbound legs of the expedition.

The gas chromatograph continuouslly analyzed the atmosphere as the vessel proceeded along its course.Sampling tubes were rigged on the bow and stern of the vessel which then connected to the gas chromatograph thereby allowing continuous sampling.The results of the analysis were then graphically recorded on paper by the plotter.At the same time that the plotter recorded the data graphically,the tape recorder recorded the results on tape. This experiment needed little assistance from the scientists.Except for putting in new tapes in the tape recorder,or making sure the plotter had enough paper,the machines ran themselves.All the data was sent to Scripps Institution of Oceanography.

The last experiment to be discussed is the dissolved nutrient study.The dissolved nutrient experiment was a study of the amounts of dissolved Phosphate and Nitrate in the equatorial waters.The water samples were obtained from the CTD experiment.The instruments utilized were a nutrient analyzing machine and a graphic recorder.

The water samples would be run through the nutrient analyzer which determines the presence and quantities of the two dissolved nutrients.The graphic recorder then records the results on paper in the form of graphs.These graphs are then sent to Scripps Institution of Oceanography for further studies.The dissolved nutrient experiment was conducted continuously on all northbound legs of the expedition.

The last four experiments discussed are without diagrams since all the instruments involved are electronic and do not have much to show except a maze of buttons,dials,and circuit boards.

This concludes the examination of instrumentation,equipment,and methods of research utilized in this expedition.There were a few small projects that took place for short periods of time but they were not the reason or basis for the NORPAX/FGGE expedition.They are therefore not discussed in this report.

The watch schedules for all the experiments was twelve and twelve beginning at 0000 hours every morning.The CTD had two men on each watch.The XBT had one man on each watch. The PCM had one man on each watch but since it required two men for launching and recovery, the XBT man or one of the CTD men assisted at those appropiate times.The SCPCM was a self sufficient operation that simply needed someone to change tapes whenever a tape was full. The XBT people usually took care of this.The buoys required three to four people per buoy launching and all the different experiment personnel who were on watch assisted on this.The solar radiation experiment was totally self operating.The only thing required was the logging of midnight and noontime in zulu (Z) on the graph.The XBT people also took care of this.The AGS experiment had one man for both watches since it was also a self operating experiment.The dissolved nutrient experiment utilized one person for both watches.If there were more people onboard, they would assist on one of the above experiments.Through the above arrangement of watches,all the experiments were properly covered and carried out.

Through the concepts of cooperation and achievement,the expedition was the success it was as people worked together towards fulfilling that goal.

Maintenance of the instruments and equipment was conducted by the different respective experiment personnel.In addition,the vessel had an electronics technician who assisted as needed.Overall,there were not many major instrument or equipment failures.There were,of course minor problems but they were remedied quickly.Should any of the equipment have broken down to the point where major repair work was needed,another piece of identical equipment would be waiting at the next port of call.Most experiments had backup units in case of failures.

The location of the experiments is depicted below in Figure 2-10.The chart depicts

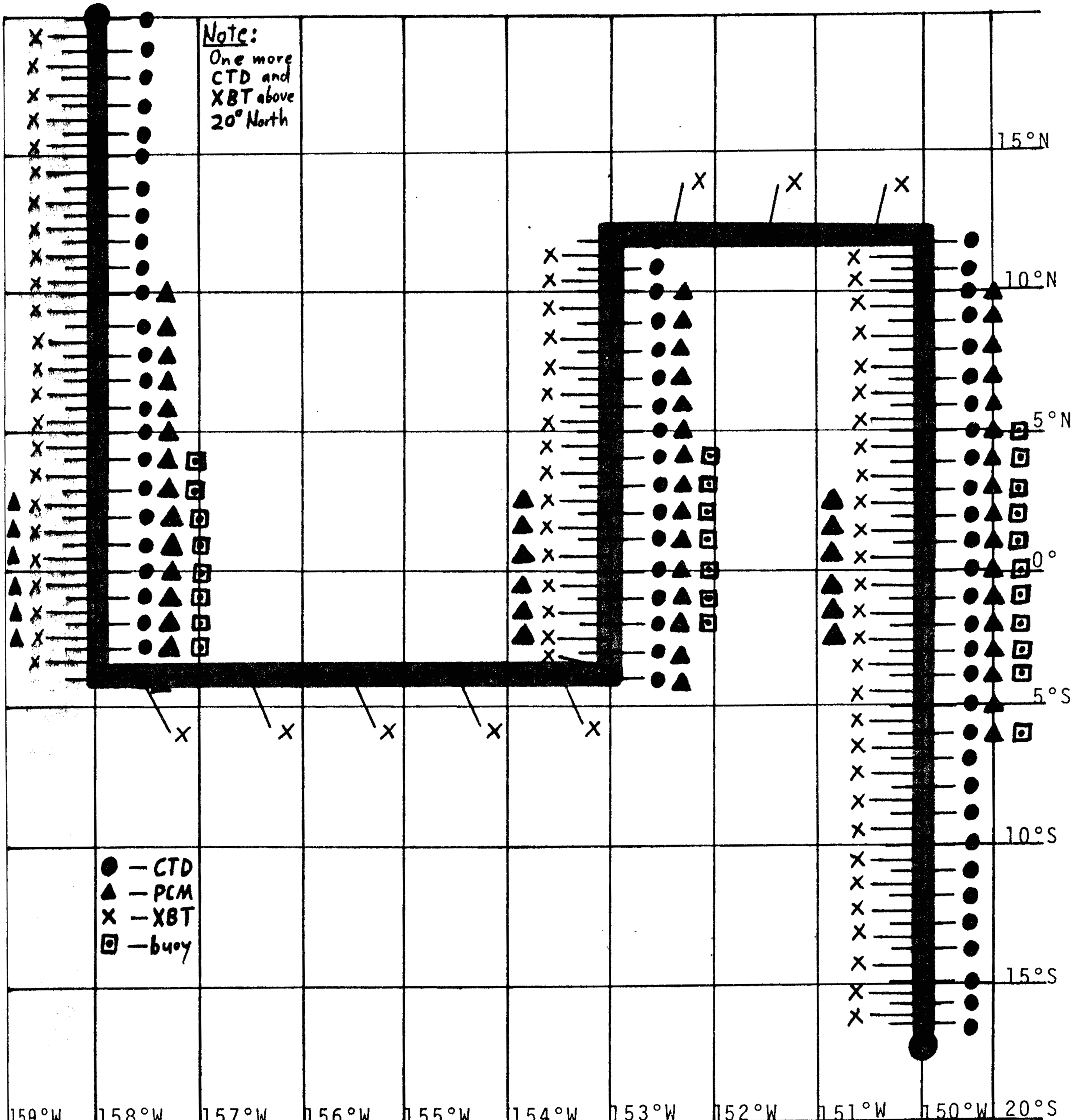


Figure 2-10.

both the courseline of the vessel as well as locations of all the experiments described in the report.The different symbols depict the different experiments.

This concludes the examination of the scientific data collection techniques used in the NORPAX/FGGE project.

III

Oceanography of the Equatorial Pacific.

The oceanography and ocean-atmosphere relationships of the equatorial Pacific Ocean examined in this report are the equatorial countercurrent,equatorial undercurrent,and the El Nino phenomena.There is of course much more to the oceanography of the equatorial Pacific but attention focuses on these three aspects as they are some of the primary reasons for the NORPAX/FGGE project.

The equatorial Pacific as defined in this report will refer to the region between latitudes 15 degrees North and 15 degrees South and extending from the Philippine,Indonesian,and Bismarck Archipelagos to the American continents.

Throughout this report,the theories,explanations,and definitions used are based upon the latest information,discoveries,and theories proposed.A brief description of the region and pertinent structures contained therein is given first to provide an overall view.

The equatorial Pacific is the tropical region of the Pacific Ocean.It is distinguished by its tropical climate,warm waters,and notable geographic features.

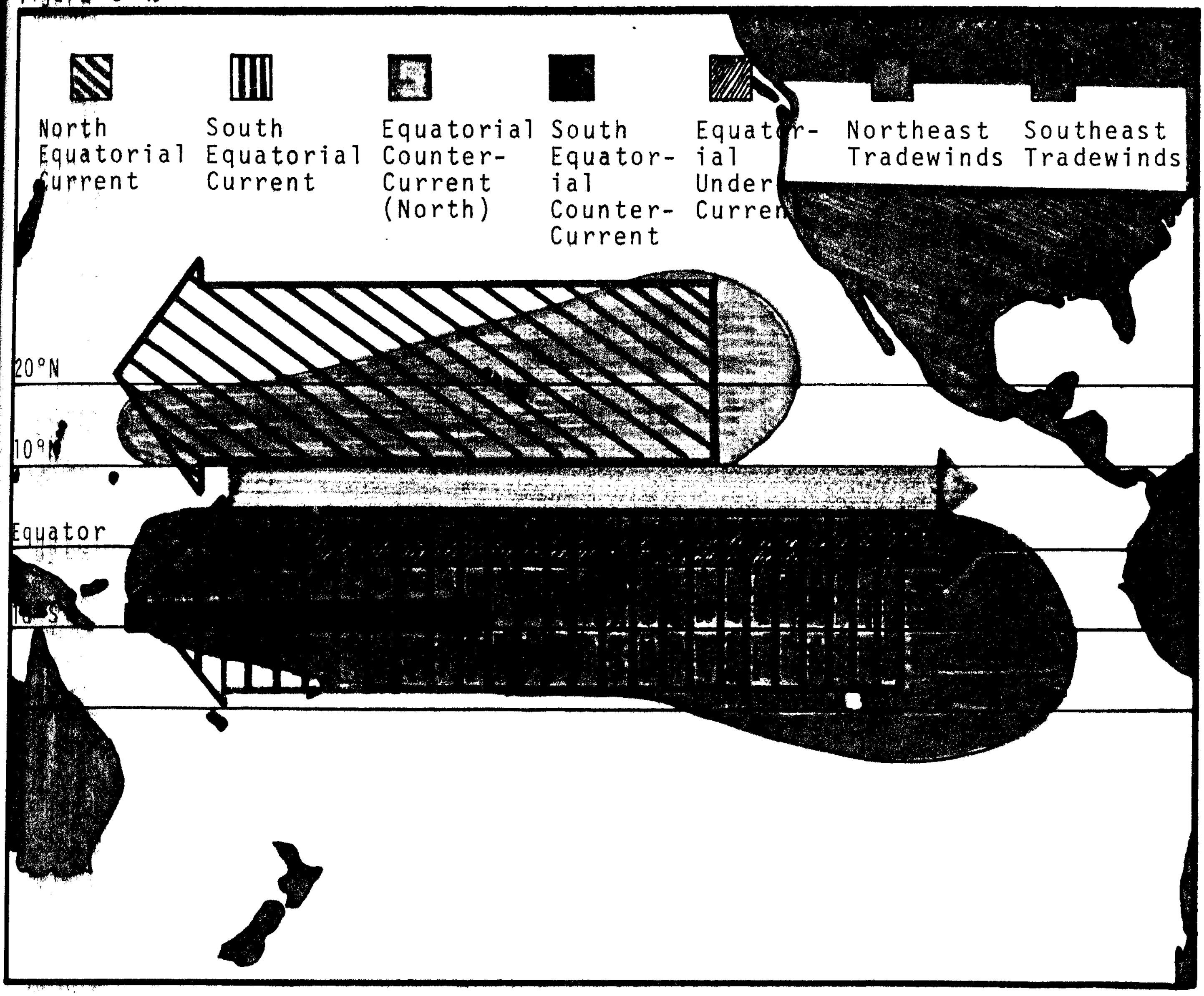
Among the important climatical features are the Northeast and Southeast Tradewinds. Both tradewinds are westward blowing winds.The Northeast Tradewinds are situated between 10 degrees North and 25 degrees North latitude.The Southeast Tradewinds are situated between 4 degrees North and 20 degrees South latitude.The area between 4 degrees North and 10 degreess North latitude is the Inter-tropical convergence zone.This is where the two tradewinds meet.Within the Inter-tropical convergence zone,the affect of the tradewinds is sharply decreased.At times there may be no winds at all.This area (Inter-tropical convergence zone) is also known as the Doldrums.Due the weak variable winds,or no winds, sailing ships dreaded the Doldrums.

TheNortheast Tradewinds are responsible for driving the North Equatorial Current.This is due to the wind stress on the surface waters which forces the surface waters to move.

The Southeast Tradewinds are responsible for the South Equatorial Current.The driving mechnism being the same as described for the North Equatorial Current.Both currents are westward flowing surface currents.

The tradewinds also play an important role in setting up the equatorial countercurrent,equatorial undercurrent,and the El Nino phenomena.The exact role they play is explained later.However from what has been explained,a schematic of the current circulation in the region can be made to facilitate understanding of what goes on.Figure 3-1 represents the schematic of current circulation in the equatorial Pacific.

Figure 3-1.



In the course of this report,the equatorial countercurrent will remain as named even though the proper name is the North Equatorial Countercurrent.The author feels that

that current is the only true countercurrent aside from the equatorial undercurrent. The South Equatorial Countercurrent is small,not well understood,and apparently only a monsoon season phenomenon.

Also to be noted is that the Southeast Tradewinds have a larger wind field than their northern counterpart.The diagram on the prior page is correct.

The tradewinds migrate in their position over the equatorial Pacific.Wherever their position may be , at a certain time (season),will accordingly influence the water mass beneath the wind field.

The equatorial Pacific is a warm water region due to the direct solar radiation of the sun.In comparison to other water regions of the world (excluding the equatorial Atlantic and Indian Oceans),the equatorial Pacific has a radical thermocline.In other words,the temperature difference between the surface waters (mixed layer) and the lower cold water mass is large.The depth of the warm surface waters is 100 meters (approximation).At 100 meters,the thermocline decreases sharply (see Figure 3-2 for depiction of the thermocline) as it enters the cold water mass.It is the warm surface

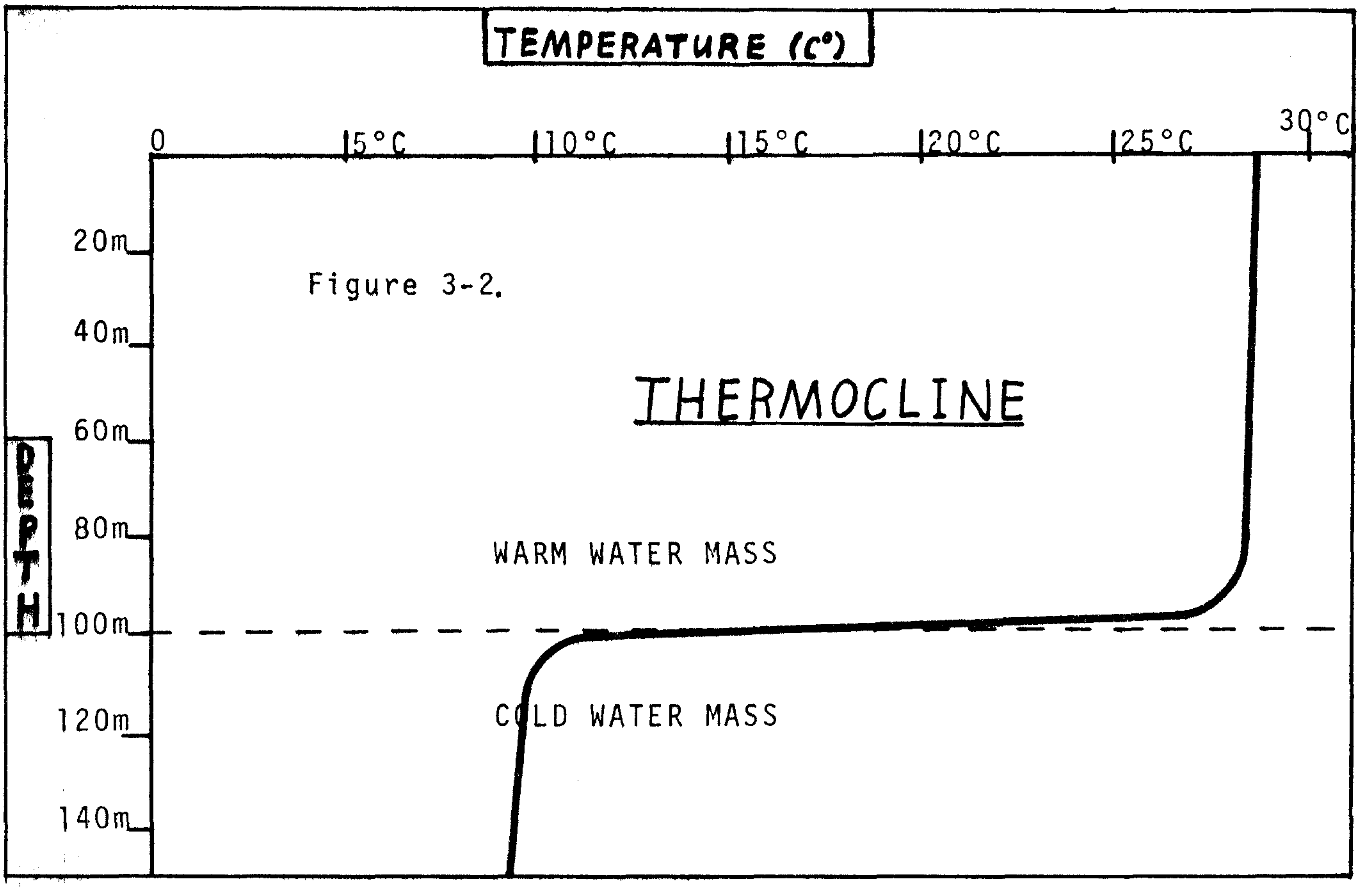


Figure 3-2.

waters that affect the actions of the atmosphere above and help form the meterological structure of the equatorial Pacific.

Among the distinguishing geographic features of the equatorial Pacific are the islands, atolls,reefs,and motus.However they themselves are not important to this report except for the fact that they are distinguishing features and that they provide excellent bases from which oceanographic expeditions can be conducted.The point to be made is that the exsist in the equatorial Pacific.

A more important geographic feature to be observed is the topography of the sea surface.The sea surface is not a flat lèvel surface but instead a series of rises and depressions.The topography of the sea surface is fundamental to understanding how the equatorial countercurrent operates.In addition,the topographic structure of the sea surface plays important roles in other oceanographic phenomena.To facilitate understanding of this concept,a cross-section of the equatorial Pacific is depicted below (Figure 3-3).Though the

Figure 3-3. Meridinal profile of sea surface topography.

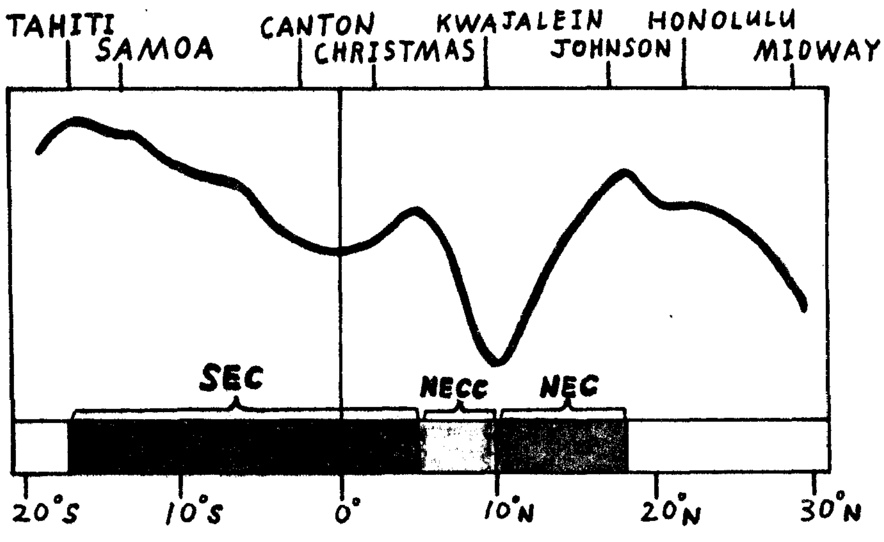
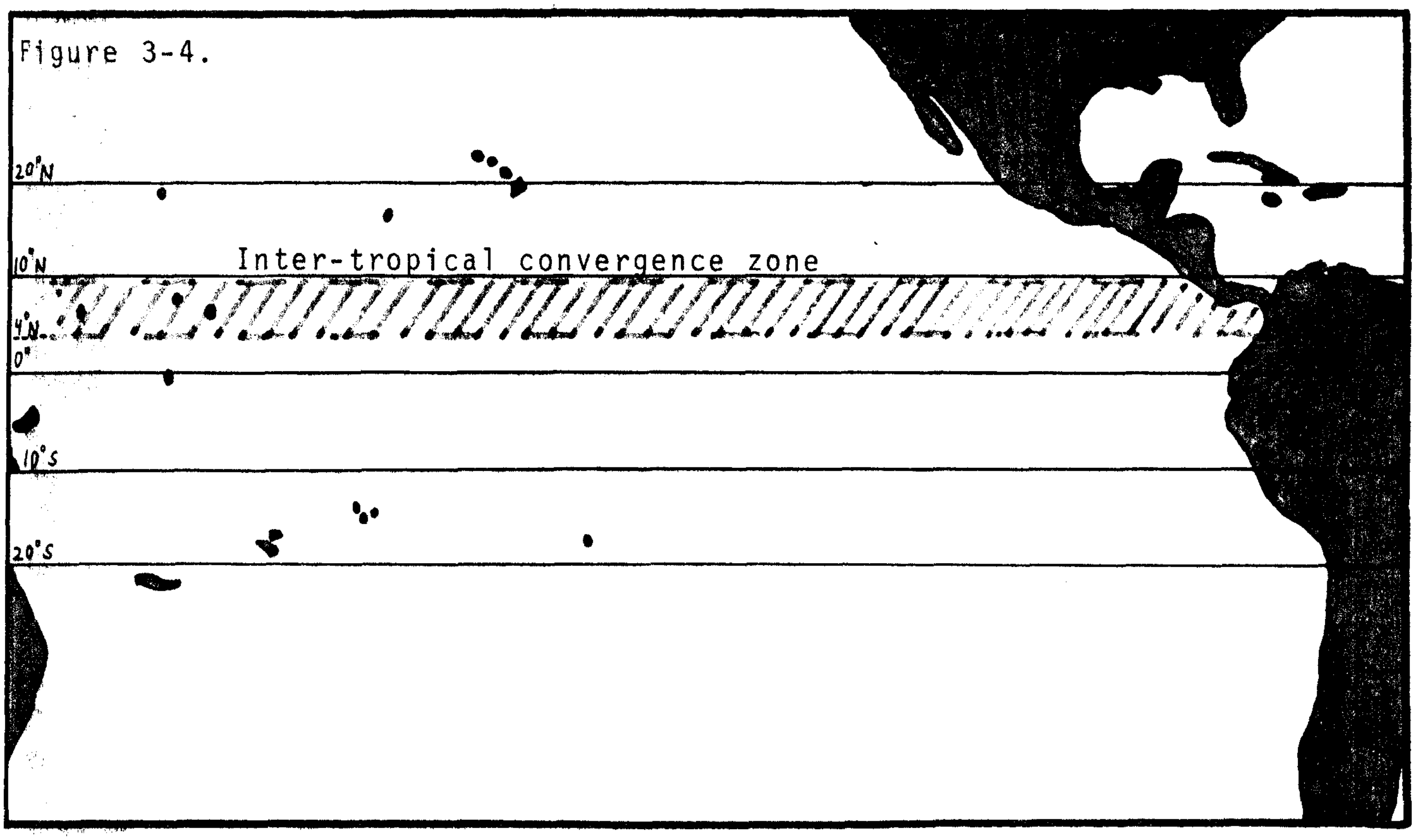


diagram exaggerates the visual aspect of the sea surface topography,the point is made that the sea surface is not level.The tradewinds are one of the forces responsible for creating the sea surface topography due to their wind stress (atmospheric forcing).

One item that the author would like to define is the concept of forces. Forces are easily comprehended if they can be seen or felt.But when you deal with forces that are not observed by your senses,these forces take on an abstract quality.Among the types of forces that are not easily observerable are the geostrophic forces.Examples are the Coriola's force,pressure gradients,and flow forces between different isothermal masses. These forces exsist and behave according to the Laws of Physics.It must be accepted that these forces exsist.Also the way forces behave and that they seek an equilibrium between themselves must be accepted.If one does not accept these facts,they are then challenging our very exsistance and the way the world operates.

The equatorial countercurrent is an eastward flowing surface current.It exsists as a band of moving water located between 4 degrees North and 10 degrees North and stretching the length of the equatorial Pacific (see Figure 3-4).The latitudinal boundaries of the equatorial countercurrent coincide exactly with those of the Inter-tropical convergence zone.The reason being that the Inter-tropical convergence zone is part of the driving

Figure 3-4.



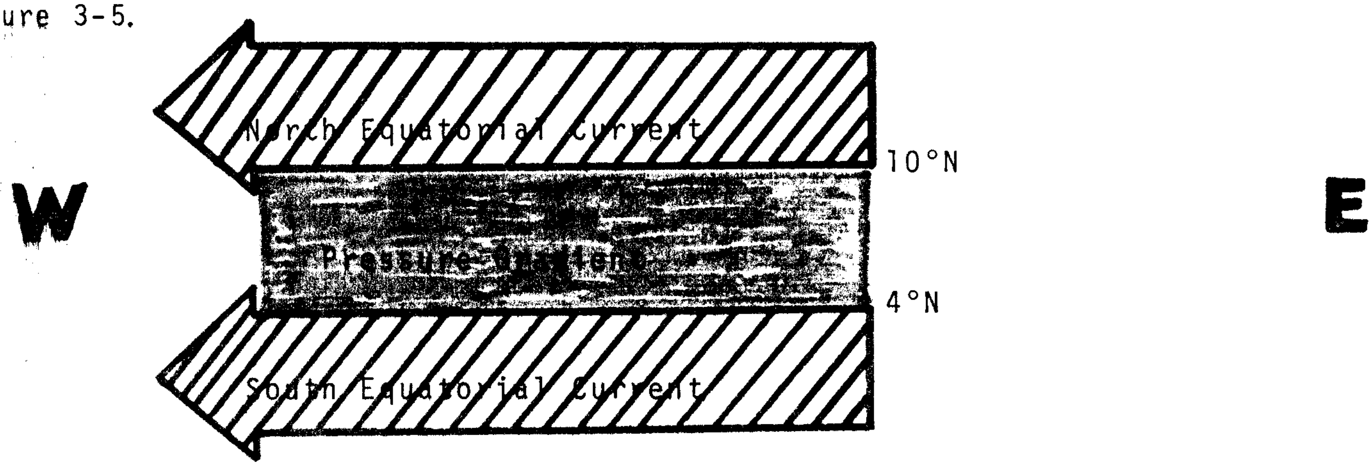
mechnism for the equatorial countercurrent.To be more specific,it is the geostrophic balance between the pressure gradient produced in the Inter-tropical convergence zone, and the Coriola's force which drives the equatorial countercurrent.

The pressure gradient is produced by the convergence of the Northeast and Southeast Tradewinds.The convergence of these two wind patterns creates an area of confused,dis-rupted,variable winds.This area is,of course,the Inter-tropical convergence zone.Since the wind pattern is weak and ill-defined,there is a lower mean wind stress on the ocean surface.The lower mean wind stress sets up a pressure gradient in that area.This pressure gradient becomes a counteracting force to the Coriola's force.These two forces jointly maintain a balance between them that drives the equatorial countercurrent.

The Coriola's force is a deflection of motion caused by the rotation of the Earth on its axis.This is based on the Laws of Physics of rotating spheres and motion upon the surfaces of such spheres.Since the equatorial countercurrent is in the northern hemi-sphere and all motion in the northern hemisphere is deflected to the right of its intend-ed path,the driving mechnism behind the countercurrent is accordingly affected as well.

The situation that develops is that the pressure gradient,which is stuck between two well defined currents (Figure 3-5),is acted upon by the Coriola's force.The pressure

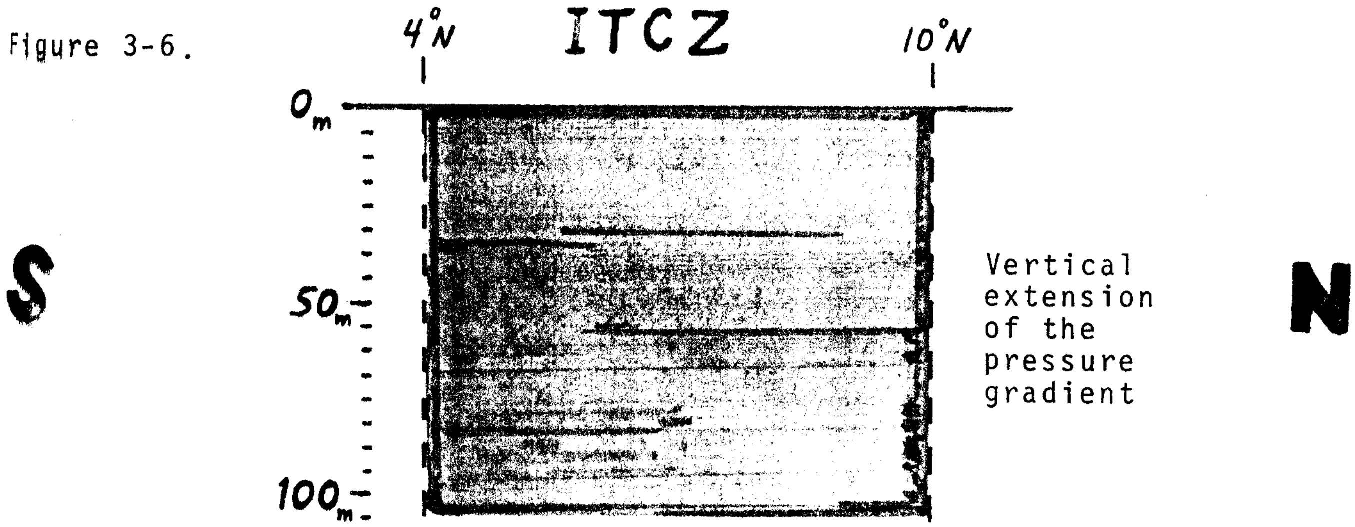
Figure 3-5.



gradient exerts an opposing force to resist the Coriola's force.This is due to a combi-nation of the vertical baroclinic structure of the pressure gradient and the topography of the sea surface.

The pressure gradient extends in depth to 100 meters (arbitrary approximation) below the sea surface within the defined boundaries of the Inter-tropical convergence zone. Figure 3-6 depicts the below surface boundaries of the pressure gradient.

Figure 3-6.



The topography of the sea surface in the Inter-tropical convergence zone slopes downward from 4 degrees North (the southern extent of the Inter-tropical convergence zone) to 10 degrees North (the northern extent of the Inter-tropical convergence zone).Figure 3-7 depicts the topography of the sea surface in the Inter-tropical convergence zone.Since

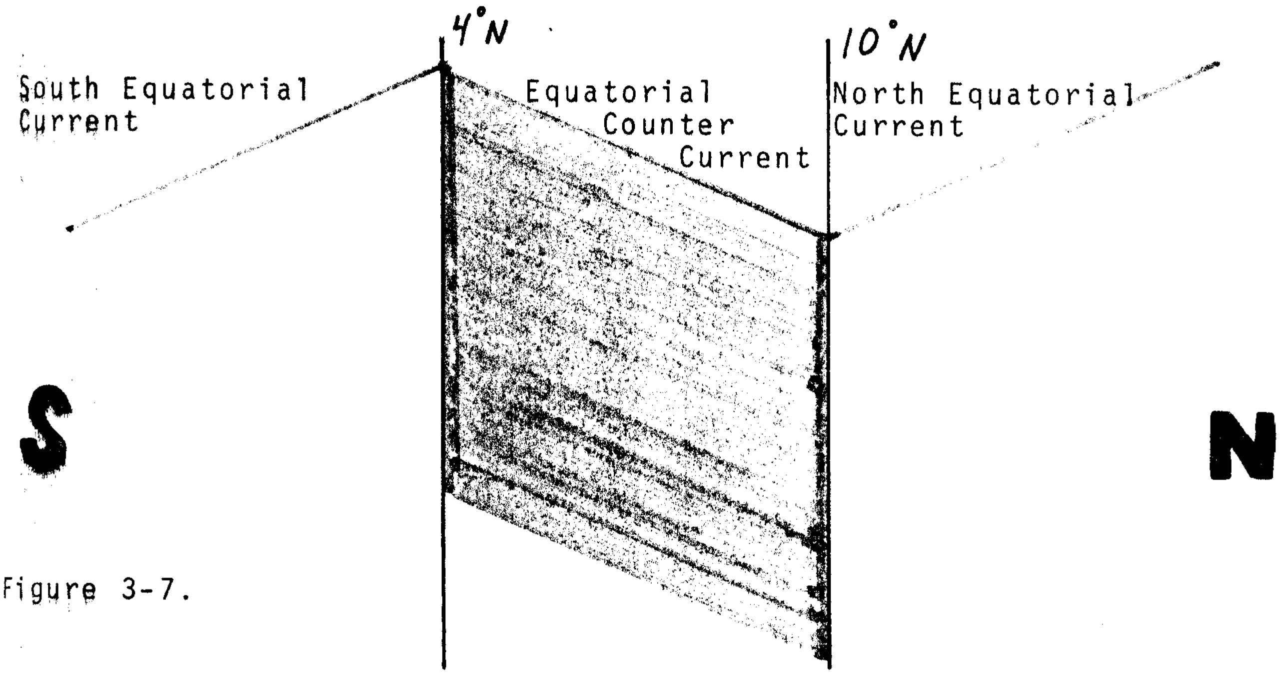
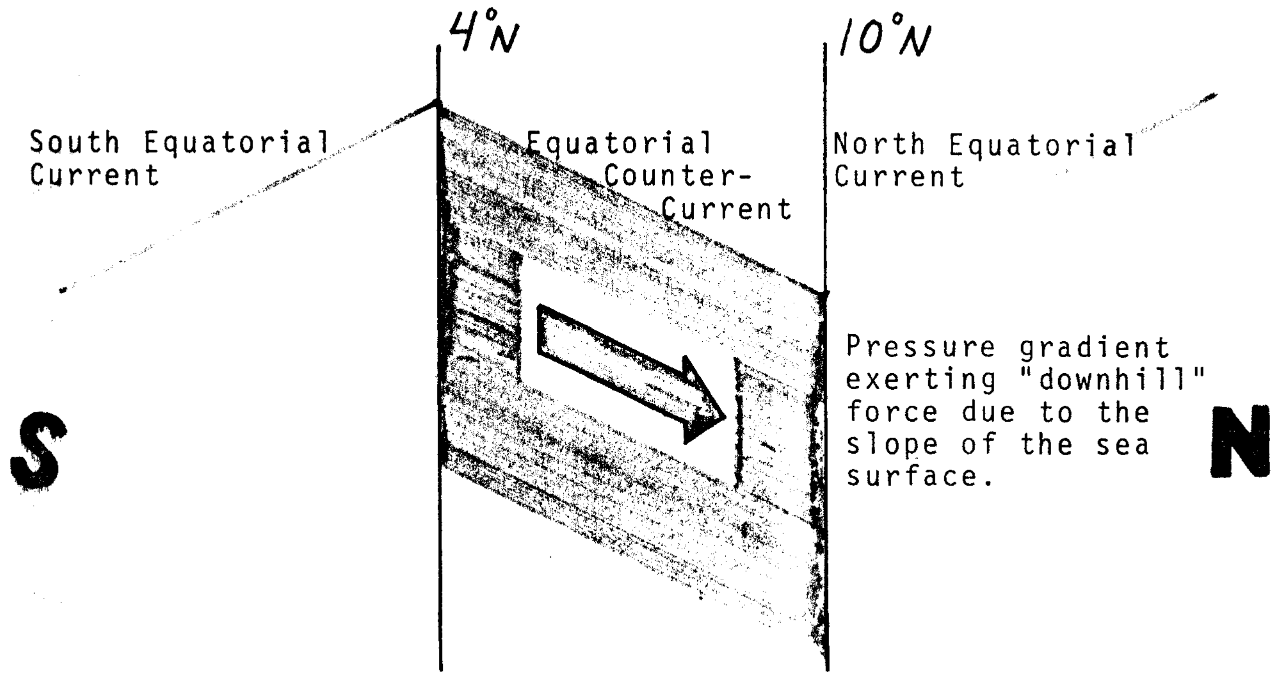


Figure 3-7.

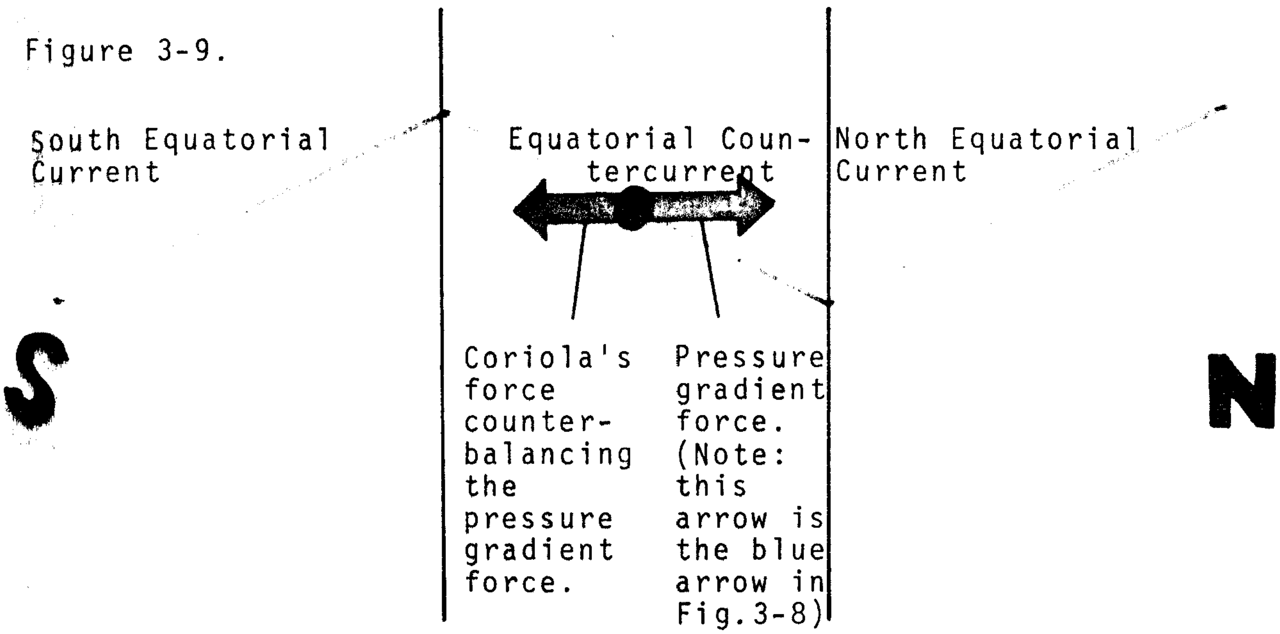
the sea surface is sloped downward to the north,the pressure gradient exerts a force in this direction.Figure 3-8 depicts the direction of the force exerted by the pressure gradient (following page).This is because the pressure gradient wishes to go "downhill".

Figure 3-8.



The Coriola's force assumes the role of counter-balancing the pressure gradient force by opposing the pressure gradient force. Figure 3-9 depicts the opposition of forces. From

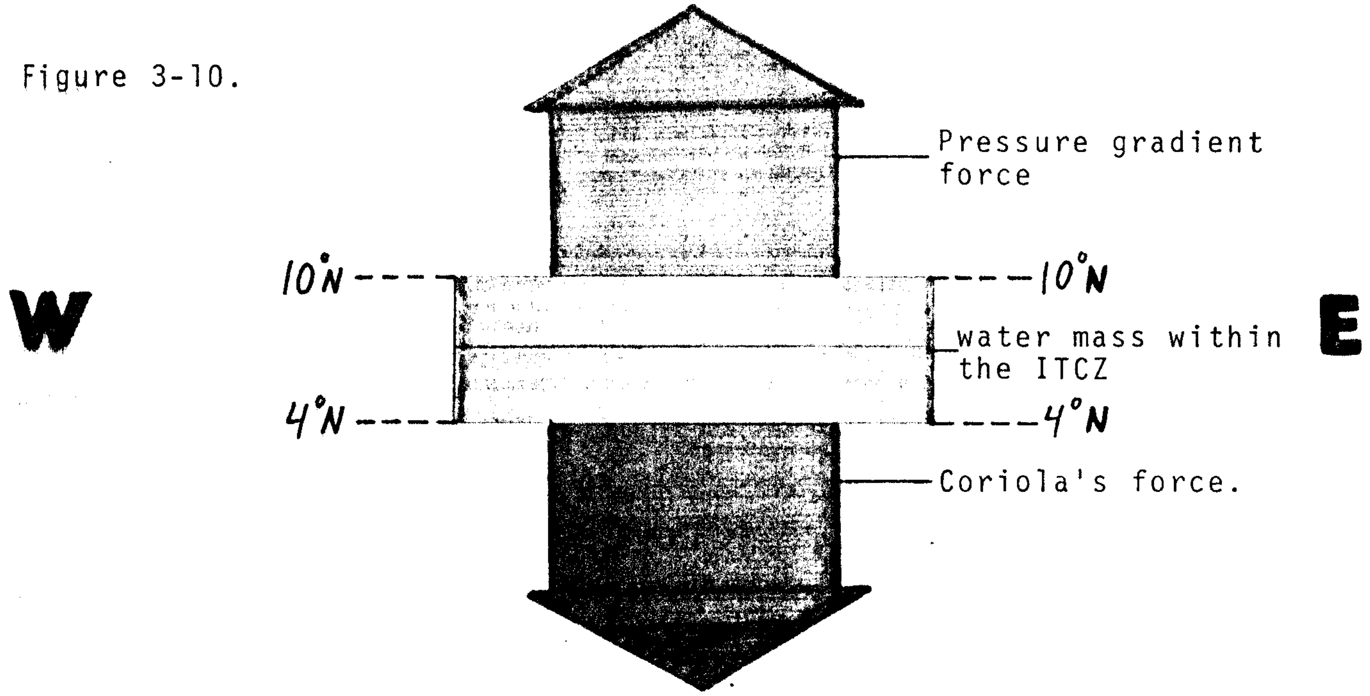
Figure 3-9.



above, looking down on the sea surface, the set-up of forces appears as depicted in Figure 3-10 on the following page. The reason for the Coriola's force counter-balancing the pressure gradient force is the Laws of Nature (they include the Laws of Physics) which stipulates that forces must be in balance. A single force can not exsist unless there is another force to counteract it. There must be an equilibrium of forces in Nature.

Due to the force structure that is set-up, motion is derived. The motion takes the form of a current that transports water. The current is the equatorial countercurrent. The cur-

Figure 3-10.

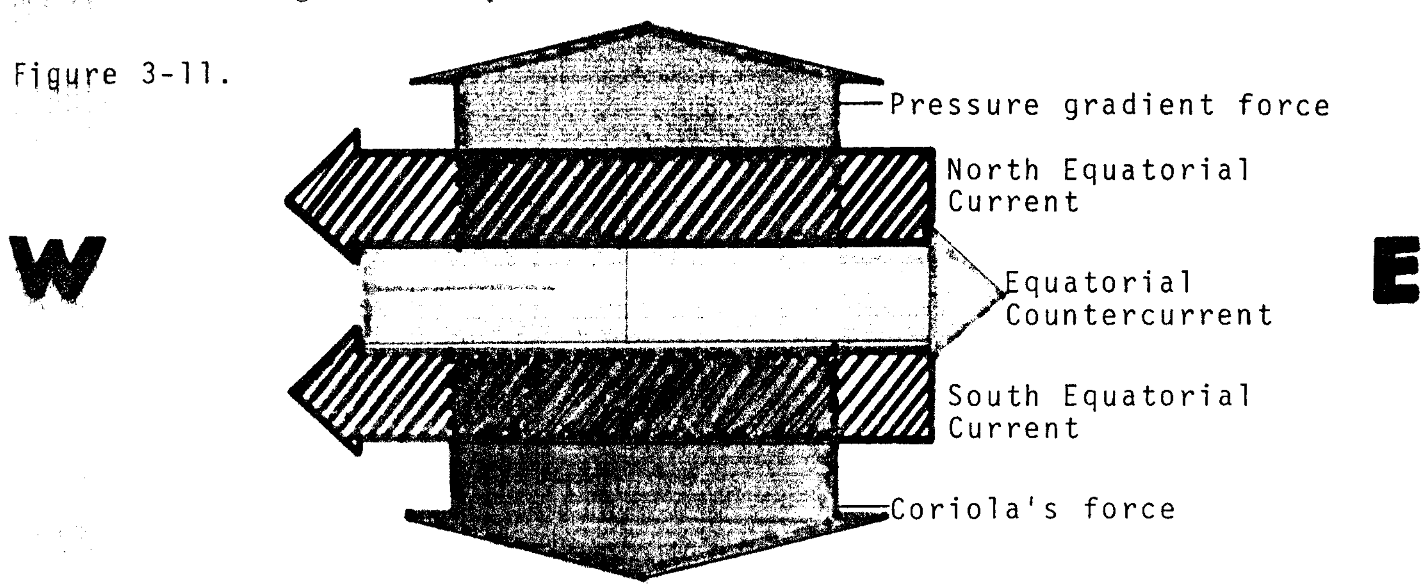


rent is a shallow (100 meters) warmwater current that only transports water located within the pressure gradient.As long as the forces responsible for inducing motion exsist,the current will exsist.

This current is a geostrophic transport mechnism since it is the result of geostrophic forces.

The current is eastward flowing due to the positioning of the forces with the Coriola's force pushing towards the Equator.It must be remembered that the Coriola's force always influences a motion to the right (northern hemisphere) of its intended path.Since the Coriola's force is opposing the pressure gradient force by pushing southward,the flow of water must be eastward.Figure 3-11 depicts the total structure of forces and currents involved.

Figure 3-11.



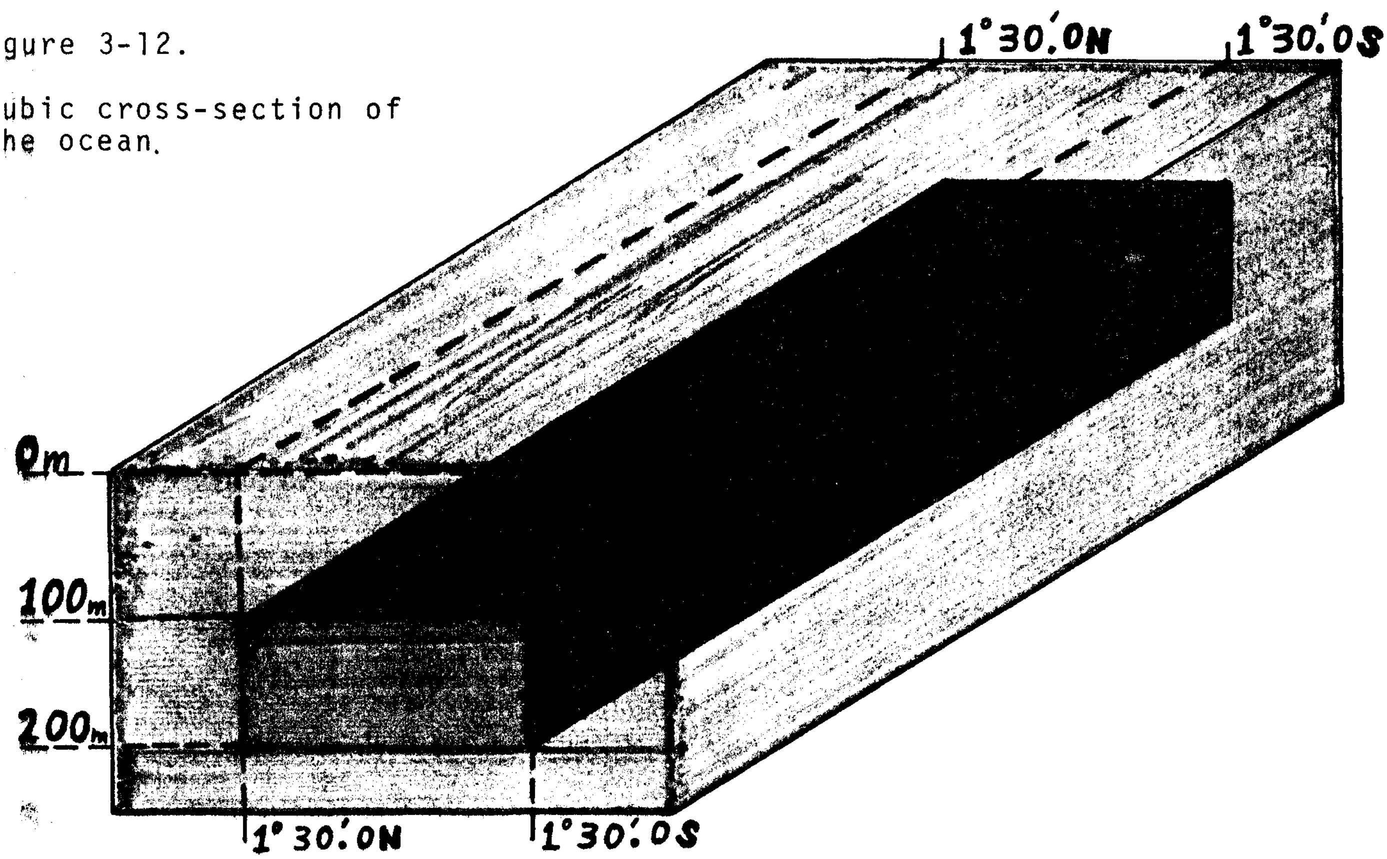
The equatorial countercurrent varies in intensity and location depending on the season. The equatorial countercurrent tends to be strongest in the fall and weakest in the spring. The intensity of the equatorial countercurrent coincides with that of the North Equatorial Current. The intensity of the currents is due to the fact that the Northeast Tradewinds have moved northward and the wind stress is more focussed on the area of the North Equatorial Current. The North Equatorial Current therefore is intensified. Since the Northeast Tradewinds have moved north, the pressure gradient is intensified as well. Therefore the equatorial countercurrent is intensified.

The equatorial countercurrent is believed to be one of the means by which the warm-water mass that produces the El Nino phenomena is transported. Associations between the El Nino phenomena and strong transport in the equatorial countercurrent have been found. Prior to some of the El Nino occurrences, there have been intense equatorial countercurrents. However the exact relationship has not yet been defined.

The equatorial undercurrent is a subsurface eastward current. The equatorial undercurrent is a band of flowing water situated between 100 to 200 meters in depth and positioned between 1½ degrees South and 1½ degrees North latitude (see Figure 3-12).

Figure 3-12.

Cubic cross-section of the ocean.



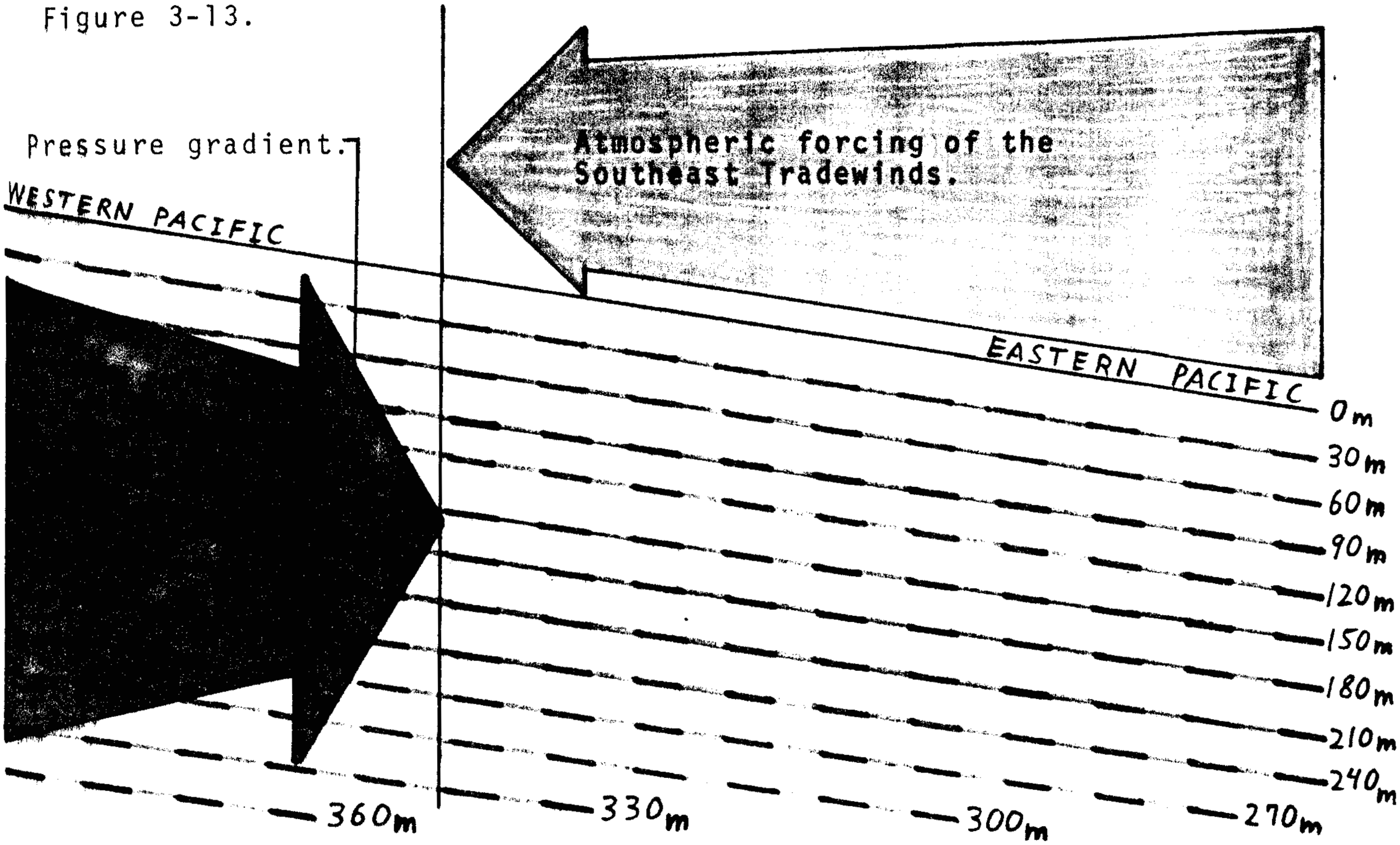
The equatorial undercurrent is underneath the South Equatorial Current.The South Equatorial Current is a westward flowing surface current.The boundaries that are given are generalized for the sake of discussion.It must be remembered that the boundaries fluctuate.The exact depth or latitudinal extent will depend on the season.

The equatorial undercurrent begins in the western Pacific where the "driving force" of the current is located.The "driving force" of the equatorial undercurrent is a pressure gradient produced by the Southeast Tradewinds.The pressure gradient is a counteracting force to the atmospheric forcing of the winds.These two forces maintain an equilibrium between them as long as the Southeast.Tradewinds blow.(It must be noted that the pressure gradient is a result of the continuous westward blowing of the Southeast Tradewinds across the Pacific Ocean.)The overall effect is,however the building of a "force system" in the western Pacific.It is this "force system" that is also responsible for the El Nino phenomena (described later in this chapter).Due to the specific way that the "force system" is structured,the force system becomes a dominating force that induces movement of the water.

The pressure gradient is the part of the "force system" that actually initiates the flow of the equatorial undercurrent.The reason that the pressure gradient induces subsurface motion of the water is the vertical baroclinic structure (depth of the pressure gradient) of the pressure gradient in the ocean.The pressure gradient which is a response to atmospheric forcing (wind),is positioned in the western Pacific and extends from the surface down towards the bottom.The exact lower depth limit of the pressure gradient is undefined as it is not known.However it may be assumed that it extends down to 200 meters at minimum since that appears to be the lower depth limit of the current.Due to this deep extension of the pressure gradient below the surface,the atmospheric forcing of the winds has no opposing affect on the lower depths of the water mass.Therefore — the pressure gradient regulates water motion in the lower depths.Figure 3-13 depicts the two forces as they are set-up in the western Pacific.

The surface water mass (0 - 100 meters) is affected by the atmospheric forcing of the winds.Therefore the surface waters move westward.This westward surface motion of the water is the South Equatorial Current.

Figure 3-13.

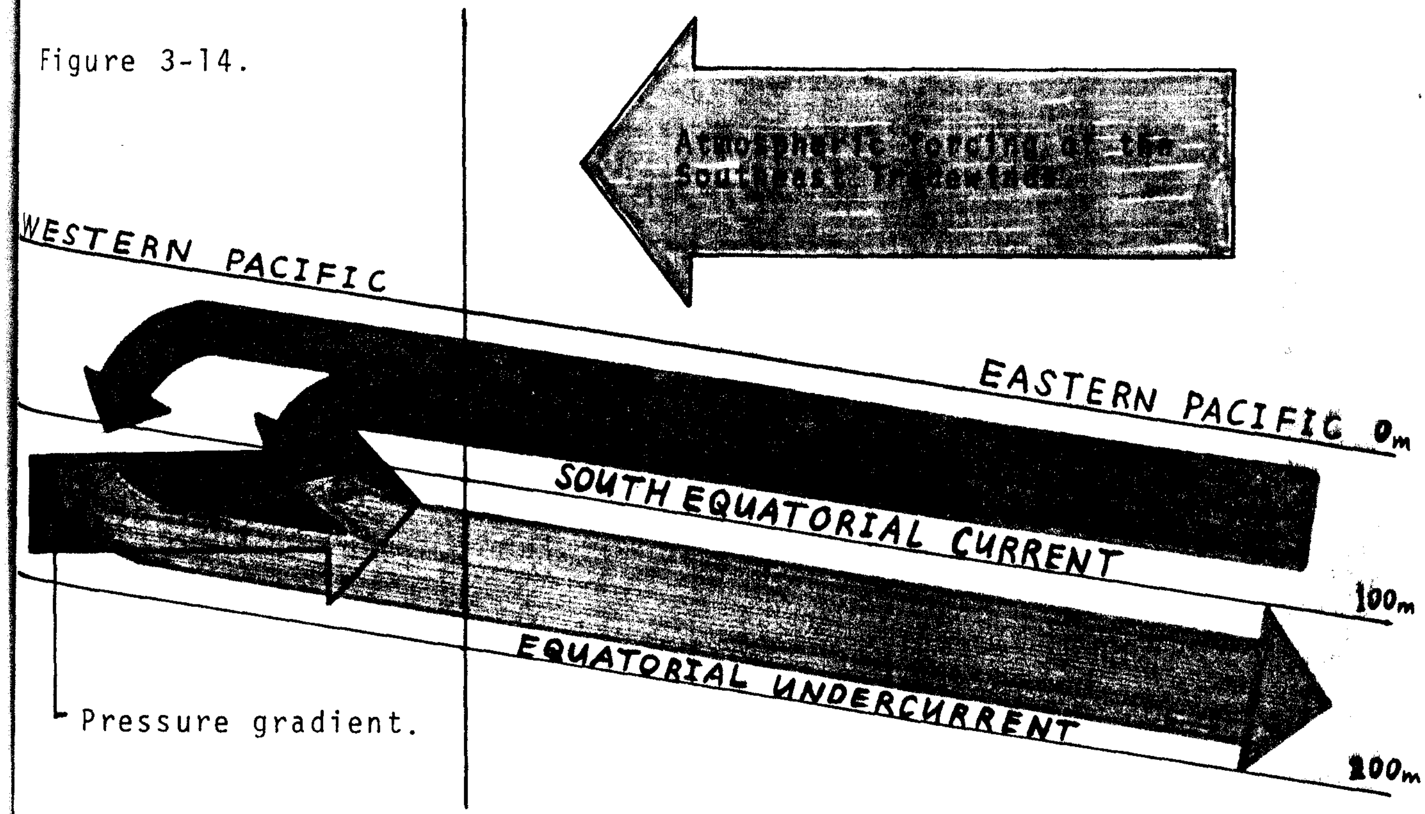


Since the pressure gradient and the "wind force" are balancing each other in the surface layer,the pressure gradient has no effect on the surface waters.However,as stated,the atmospheric forcing of the winds loses effect on the water mass as depth increases.Soon a point is reached where the atmospheric forcing of the winds has no effect and the pressure gradient becomes dominant.This is where the equatorial undercurrent is born.It must be remembered that the atmospheric forcing of the winds is a westward pushing force. Therefore the pressure gradient is an eastward pushing force (since it opposes the atmospheric forcing of the winds).Where the pressure gradient is dominant,motion will be eastward.Below 100 meters the pressure gradient pushes water eastward as there is nothing to hold it back.This eastward directed motion of water is the equatorial undercurrent.Figure 3-14 depicts the currents and "force system" of the western Pacific.

The eastward pushing of the water mass by the pressure gradient extends down to 200 meters (arbitrary approximation).This has been established from current studies of the equatorial undercurrent.Below 200 meters,the undercurrent does not exsist.Therefore it may be assumed that the pressure gradient is relatively "forceless" below 200 meters.

The equatorial undercurrent is undoubtably a mechnism for keeping the Pacific Ocean

Figure 3-14.



in balance.The equatorial undercurrent is the mechnism for returning the waters brought westward by the South Equatorial Current.If there wasn't the undercurrent to return the water transported west,there would then be a pile up of water in the western Pacific. Unequal mass distribution would exsist since the eastern Pacific would have less water. Since the Laws of Physics concerning fluids,mass distribution,and equilibrium would be violated,the undercurrent is the balancing mechnism.The equatorial undercurrent is not the only balancing mechnism but one of many that together keep the Earth in balance.

Throughout this discussion of the equatorial undercurrent,the diagrams have depicted the ocean surface as a slope that increases from east to west.The reason for such depiction is that the surface of the western Pacific is higher than the surface of the eastern Pacific.This is due to the atmospheric forcing of the winds.The Southeast Tradewinds drive the surface waters west so that the western Pacific accumulates more water mass. Even though there is the undercurrent and other transport mechnisms for returning the water,they are not sufficient to prevent a slight buildup of water mass in the western Pacific.The area of water mass buildup in the Pacific is between Samoa and the Solomon Islands.Therefore the sea level is raised in the western Pacific.As long as the Southeast Tradewinds blow and the "force system" stays in effect,the slope will exsist.Only when the Southeast Tradewinds cease will the slope decrease to a level surface.This is because there are no forces to prevent equilibrium of masses.

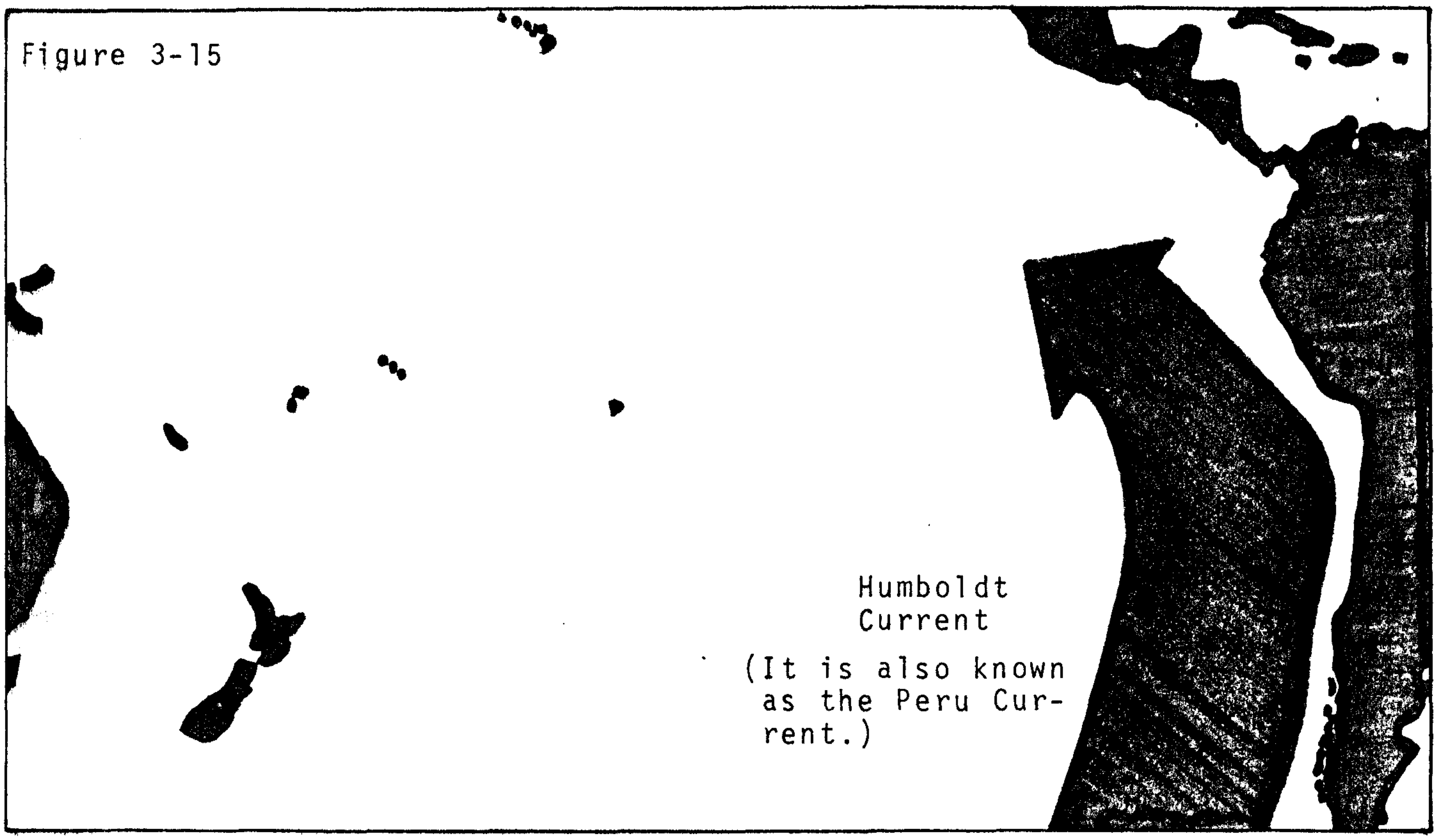
The equatorial undercurrent is an all-year current that flows continuously.This is due to the steady Southeast Tradewinds that blow most of the year.Even when the Southeast Tradewinds have slacked or ceased,the undercurrent continues.When the winds have ceased (summer season-southern hemisphere),the undercurrent increases in intensity since the pressure gradient is no longer opposed at all.The pressure gradient begins collapsing which intensifies the eastward puhing of the water mass --- as well as triggering the El Nino phenomena.Also when the Southeast Tradewinds are strongest (winter season-southern hemisphere),the undercurrent is intensified.This is because the pressure gradient is equally intensified in opposing the atmospheric forcing of the winds.Through the interaction of the atmospheric forcing of the Southeast Tradewinds and the counter-balancing pressure gradient,the equatorial undercurrent is derived.

The El Nino phenomena is the development of a large warm water mass off the westcoast of South America.The importance in understanding the El Nino phenomena is crucial to preventing the economic havoc it inflicts on the nation of Peru.If the El Nino phenomena can be defined and understood,the economy of Peru can be structured appropiately such that they cope with it.

The ocean region off the westcoast of South America is normally a coldwater region. This is due to the Humboldt Current which transports cold water from the Antarctic region northwards towards the equatorial region of the Pacific Ocean.Figure 3-15 depicts the Humboldt Current.

The cold water is essential for providing nutrient rich surface waters.By having cold water throughout the water column,upwelling occurs.Upwelling is the mixing process in the water column where nutrients are brought from the bottom to the surface.Figure 3-16 depicts the upwelling process.The upwelling process,which occurs normally in that region,is necessary for maintaining the anchovy and guano industries which are the backbone of the Peruvian economy.However with the occurrence of the El Nino phenomena,the upwelling process is destroyed.

Figure 3-15



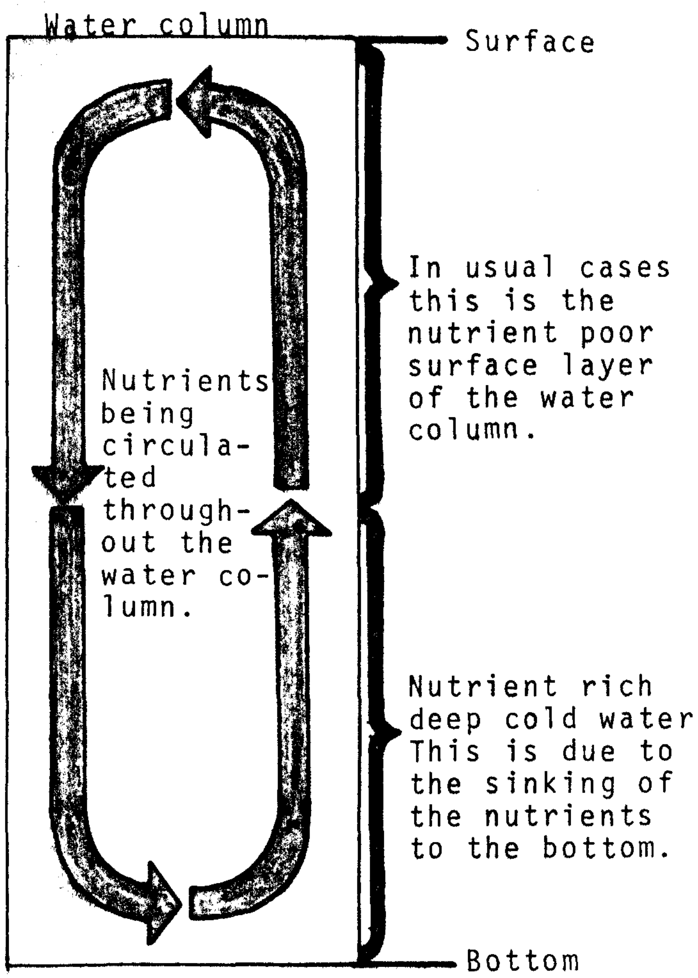
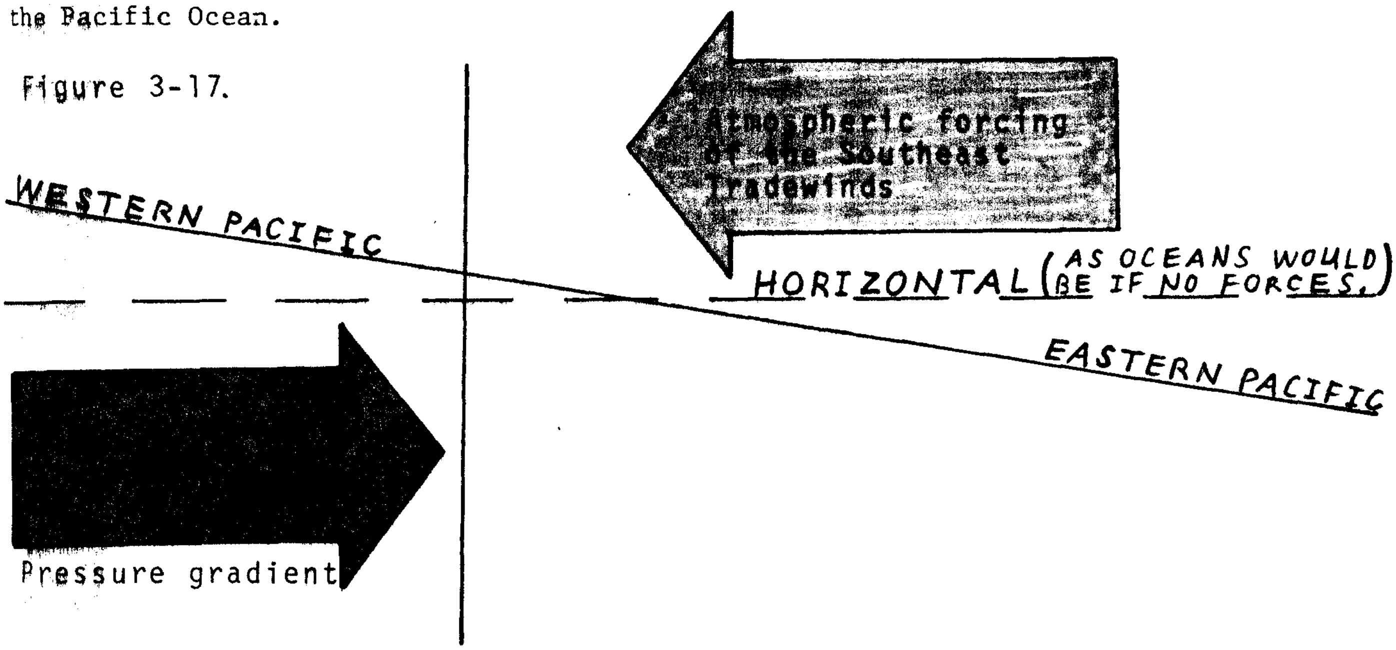


Figure 3-16.

By having cold water of the same or similar temperatures throughout the water column from the surface down,the upwelling process can occur.There is no stratification or lay-ering of different thermal water masses in the water column that prevents the nutrient circulation (upwelling process) from occurring.

The El Nino phenomena begins in the western Pacific when the Southeast Tradewinds have ceased blowing or slackened considerably (summer season-southern hemisphere). The El Nino phenomena is a response to atmospheric forcing. The Southeast Tradewinds are the source of the atmospheric forcing. The Southeast Tradewinds blow continuously across the equatorial Pacific from east to west creating a pressure gradient in the western Pacific (just as in the case of the equatorial undercurrent). The pressure gradient is a direct result of the wind stress on the ocean. The pressure gradient is the counteracting force to the atmospheric forcing of the winds. These two forces simultaneously build thereby maintaining an equilibrium between them. Figure 3-17 depicts the two forces as set up in the Pacific Ocean.

Figure 3-17.



However even though the forces themselves maintain an equilibrium between them, the net effect is the building of a "force system" in the western Pacific. Reference is made to Figure 3-13, Figure 3-14, and Figure 3-17 which all depict the sloping surface of the ocean with the western Pacific higher than the eastern portion. These diagrams interpreted correctly show a slope from west to east with the "force system" on the higher part of the slope (western Pacific). This whole structure of forces is maintained as long as the Southeast Tradewinds blow. The set-up of forces just discussed is the prevailing state of forces in the region (aside from others).

When the Southeast Tradewinds stop blowing, then the "force system" is disrupted. The equilibrium of forces is no longer maintained.The "force system" begins to collapse.This is when El Nino begins.The collapse of the "force system" is the triggering mechnism for El Nino.What has happened is that the atmospheric forcing of the winds is no longer existent and all that is left is the pressure gradient which can not support itself.

The pressure gradient begins collapsing by signalling the return of the ocean to equilibrium as it would be if there were no forces.One of the signals emitted is the Kelvin wave which is the signal for El Nino.It is this signal that is important to understanding the El Nino phenomena.

The Kelvin wave is a low freqency sinusoidal wave of motion that is emitted as the pressure gradient collapses.Figure 3-18 depicts the Kelvin wave.This wave then travels

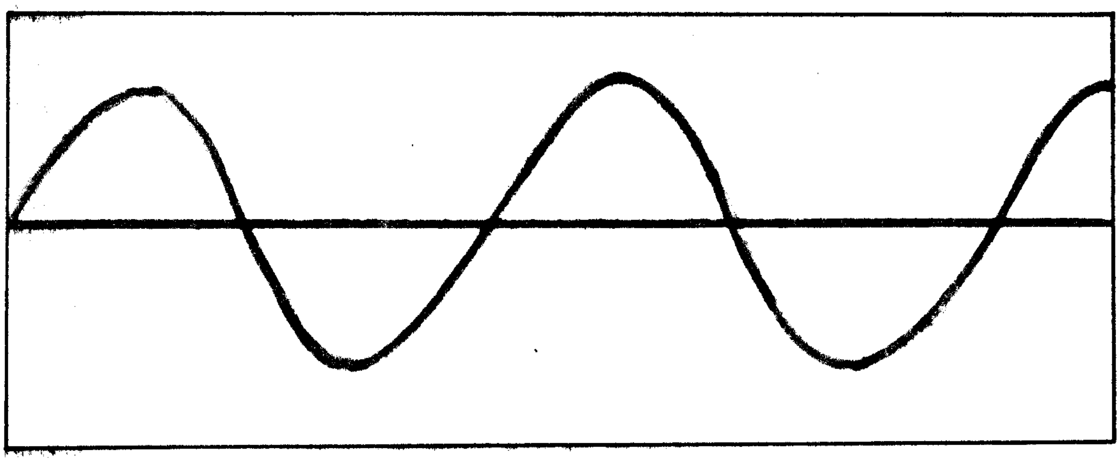


Figure 3-18.

The Kelvin Wave.

through the ocean.The Kelvin wave for El Nino travels from the western Pacific to the eastern Pacific.When the Kelvin wave reaches the eastern Pacific (off of South America), it signals the thermocline to increase its depth.It is the increase in depth of the thermocline that stops upwelling.

The thermocline is the temperature structure of the ocean with increasing depth.In the equatorial regions of the Pacific,the thermocline is normally found at depths of 90 - 125 meters below the surface except for the region off of Peru.It must be remembered that the thermocline itself is the part of the temperature profile that radically shifs from warm to cold water due to the difference of temperature between the warm surface water mass and the deeper cold water mass.Until now the role of the thermocline has been excluded but it now needs explanation.

The thermocline,when the Southeast Tradewinds are blowing and the "force system" is set-up,is normally shallow off of Peru.In other words,the warm surface water mass does not have much depth at all.The water column,except for the uppermost part,is cold.Upwelling can occur,since the temperatures of the water column are the same,and the anchovies have their food (nutrients).But when the Southeast Tradewinds stop blowing,the Kelvin wave is sent out (pressure gradient collapsing) which signals the thermocline off of Peru to increase in depth.

A large warm water mass begins to develop on top of the normally cold water mass.The source of the warm water is the flowback of water from the western Pacific via the equatorial countercurrent.The warm water mass stratifies the water column due to the differences of temperature and the upwelling process is terminated.Since no nutrients are brought up to the surface --- the anchovies die.(The anchovies are a surface water fish and therefore can not go down to the depths of the cold water mass where the nutrients are now located.)It is the shift of the thermocline and accumulation of a large warm water mass on top of the cold water mass that is the El Nino phenomena.

El Nino is an annual thing (seasonal) since it is a response to the cessation of the Southeast Tradewinds.The El Nino occurs at Christmas time --- hence its name.Christmas time in the southern hemisphere is the summer season.There is a time lag between the time that the winds have ceased and the development of El Nino but it is minor.The correlation between them is distinct.The problem with defining El Nino is its seven year phases of catastrophic magnitude as opposed to the yearly barely noticeable occurrences.This is demonstrated by its occurrences in 1957-58,1965-66,1972-73,and 1979 --- though not as catastrophic.As far as before 1957,no one knows.The author contends that El Nino did indeed occur before 1957 but it had no effect on mankind as mankind was not as involved with the ocean to the same degree as he is today.

One reason that El Nino has become so visible is overfishing.Today mankind is so greedy for all that he can get that he takes everything without regard to tomorrow or nature.Before the 1957-58 El Nino,the level of fishing was not at the large scale as it is today.Therefore there was no depletion of the fish stock.Nature could compensate for its losses.

However beginning with the 1950's,fishing increased to larger and larger proportions. Soon the maximum yield rate was reached and then it was surpassed.Then in 1957 when the El Nino occurred,everyone got a suprise.There were no fish!While mankind can not control the El Nino phenomena,he can control the level of fishing.By not taxing such a demand on the fish population,nature can cover for its losses.If the fishing limit were to be decreased to a safe consumption rate,the El Nino phenomena would not be the catastrophy it is.

The El Nino phenomena is a two year phenomena when examined from the context of its catastrophic occurrences.The first year cycle has been described.The second year cycle has yet to be defined.To date there is no substancial theory to support its occurrence in the second year.It is suggested that the equatorial currents play a role in continuing the El Nino phenomena in the second year cycle but,as stated,it is not well understood.As for the seven year cycle of catastrophic El Ninos --- that also has yet to be understood. To date only the mechnism for producing El Nino can be explained.

IV

Research: A Question of Value.

Research in any form needs two important components --- money and time.The question raised is --- Is it worth it? To answer this question,the concept of research must be defined in terms of whether it is basic or applied research.In addition,the question must be answered in context with the economic,political,and cultural components of the nation.By defining the purpose of the research and considering the state of the nation, the question may be properly answered.On top of these aspects,the effects of the research on the rest of the world must be considered.Can a nation's research efforts (United States) be misconstrued as a means of exploitation of another nation's resources? These global implications must be considered as well.

Basic research is research for the sake of understanding some phenomena and the mechnisms behinds its exsistence.No thought is given to the practical aspects of the phenomena.In other words,basic research is research for asthetic purposes.What may be derived from the research in terms of being utilized to mankinds favor is not considered.Applied research is basicly just the opposite.

Applied research is research done in terms of the practical applications it will have for mankind.The practical applications can be economic,social,cultural,or political.In other words,there is a "profit" from doing the research.It is this difference that distinguishes basic research from applied research.With the above definitions of basic research and applied research kept in mind,the question of research being worthwhile may be attempted.

From the economic standpoint,research at sea such as the NORPAX/FGGE project is not worth it.The reason being that the majority of the project is basic research.There are no "profits" to be had.Although a part of the project is applied research (El Nino phenomena),the benefits are not to our own people.The Peruvians are the ones who benefit.What must be remembered is that the ultimate sponsor who pays for the research is the American taxpayer.When you consider the economic situation that exsists in this country today,the American taxpayer who is feeling the "squeeze" will certainly be opposed to unjustifiable spending of "his" money.In other words,what the author is saying is that an American wage earner and family that is having a hard time surviving economically would oppose the part of his or her taxes that is used to fund research such as the NORPAX/FGGE project when he or she could put that money to better use themselves.Since the majority of Americans are having to "tighten their belts",the government must as well "tighten their belts".This is in fact taking place now.Just recently,the president cut the budget of the National Science Foundation (NSF).The National Science Foundation is the division of the government that is responsible for funding research in the United States.This is not to say that the National Science Foundation is the only research funding agency.It is however the major sponsor of institutional research in the United States.

In addition,it must be noted that the people have for a long time wondered about the government's spending policy and if they were to learn of spending of money on a project that has no clear "dividends" to them in the immediate future,they would object to such spending.It is the author's belief,naive as it may be,that the people would rather have that money (which runs into the millions) spent on "supposedly" beneficial projects that return the money to them rather than satisfying some scientists theories or interests.

The fact that research projects may prove valuable later on because of an accidental discovery or additional research can not be considered in justifying their expense.That is an unknown variable that can not counted on.Many research projects have of course proven valuable later after their initial experimentation.However as stressed before, that can not be included in the justification of research now.

So far only the monetary aspect of research has been discussed.The author would like to note that if the NORPAX/FGGE project had been an applied research project,the economic value of the project may have been enhanced;depending on what the "profit" might have been.

The time component of research has no "real" value in this discussion as it doesn't justify research from the economic viewpoint.If anything,the time element is detrimental to providing justification of research.This is based on the simple philosophy that time increases spending.It would be one thing to justify the experiment (research) --- in other words,why it is needed --- but to tell the people that two years (arbitrary figure) would be needed would only make them oppose it more.Why? The answer is simply the added expense.

From the political viewpoint,research is essential.(In the particular case of the NORPAX/FGGE project,the data from the Expendable Bathythermograph experiment is of major importance.)Research is worthwhile because it helps to maintain the political state as a defined entity.This is achieved through the military and intellectual support that the political state receives from research.The type of research does not matter.

Research provides information of areas that only research experiments could obtain because of their "innocent purposes".An example is the U.S.S. Pueblo in the North Korean incident.

In the NORPAX/FGGE project,the data being collected is mostly of a scientific nature. However,among its many experiments,there is one that is intended for supporting and maintaining the United States militarily.(It is the author's belief that anything supported militarily is supported politically since political states depend on the military for support.) The experiment in question is the expendable bathythermograph (XBT) experiment which is gathering data to be utilized in submarine warfare.It must be remembered that sound travels poorly through water masses of different temperatures.By obtaining temperature profiles of the water masses (water column),submarine warfare can be effectively enhanced in terms of American strategy and superiority.This allows the United States to hide their submarines so that they achieve a strategic advantage over the enemy.

Through research experiments such as the NORPAX/FGGE project,the data needed to politically support the United States is obtained.Some may argue that the NORPAX/FGGE project is an applied research project due to the expendable bathythermograph experiment.It is not!The expendable bathythermograph is also used for scientific purposes.Also it must be remembered that the expendable bathythermograph experiment is only one of many experiments that are being conducted in the NORPAX/FGGE program.All the others are scientific in nature.In addition,it should be noted that the expendable bathythermograph experiment can be conducted in other ways that would probably be more accurate and strategically valuable.In the case of the NORPAX/FGGE project,the expendable bathythermograph had a dual role.

The intellectual aspect of supporting the United States politically by research is derived from the increasing population of educated people.It is essential that for any political entity to survive,there must be intellectuals (educated people).There are those who argue that it is better to have a population of uneducated people since that makes it easier to control them.In other words,the adage from George Orwell's novel 1984 which states that "Ignorance is Strength" is correct.The author disgrees.Intellectuals are needed to foster the well being and longevity of a political state.Through research, intellectualism is nurtured and perpetuated.Due to the liberal policies of the United States in terms of freedom of education,voice,and the right to be what you want to be, people have sought refuge in the United States.This policy has brought many educated people to this country that have then helped support this nation politically through their research efforts.

Often the intellectual and military components of the political entity go hand in hand.This has been demonstrated time after time by the defection of scientists and intellectuals to the United States and who have then given the United States some of the most potent and superior war machines that ever exsisted.

Research is necessary from the political viewpoint because of it's military and intellectual qualities.There is no way that this can be disputed!Money and time have no value in a discussion of this nature as what is being discussed is beyond such material articles.

From a cultural point of view,research is extremely worthwhile!Culture signifies the status of a nation and why it exsists in the form that it does.Culture is the essence of a nation's exsistence.Another way to descibe it is that culture is the "soul" of a country.Research plays an important role in influencing the cultural component.Whether it is basic or applied research makes no difference.

The United States has a culture based on the material objects and knowledge and skill level it has developed.The United States was built on a foundation of inventions, innovations,and technology.In every one of these aspects,research played an important part.Research permitted the inventions,innovations,and technological developments to occur.The culture that exsists today is based on the many sophisticated objects,machines, and knowledge that were derived from research.The United States is recognized by most of the world for its technologically advanced culture.All these developments and advancements signify the American culture.Research helped give the United States the position and status it has in the world.

However research must go on if the United States is to maintain its present position and status.Today many other nations are attempting to advance themselves through strong research and educational programs.The United States is losing ground to some of these foreign countries."The United States is being beaten at its own game,"if you wish to coin a phrase.The United States,therefore,must push even harder by conducting continuous ongoing research projects in all areas (not just the sea).The American culture depends on it as well as thrives on it.The image of America as a technological advanced culture must be preserved as it epitomizes what the United States of America is.

Due to the cultural importance of research,research projects such as the NORPAX/FGGE experiment must go on.They are extremely valuable and worthwhile.The NORPAX/FGGE project is just one small facet of the whole concept of research that preserves the American image.

But because of the NORPAX/FGGE project,the United States has gained a little more knowledge about the oceans that no one else may be aware of.And who knows? At a later date it may prove to be extremely valuable.At present,the United States is just preserving its image and maintaining its culture by supporting the NORPAX/FGGE project.

The research concept is mandatory if the United States is to survive culturally.

Research both nurtures and pertuates the American culture.

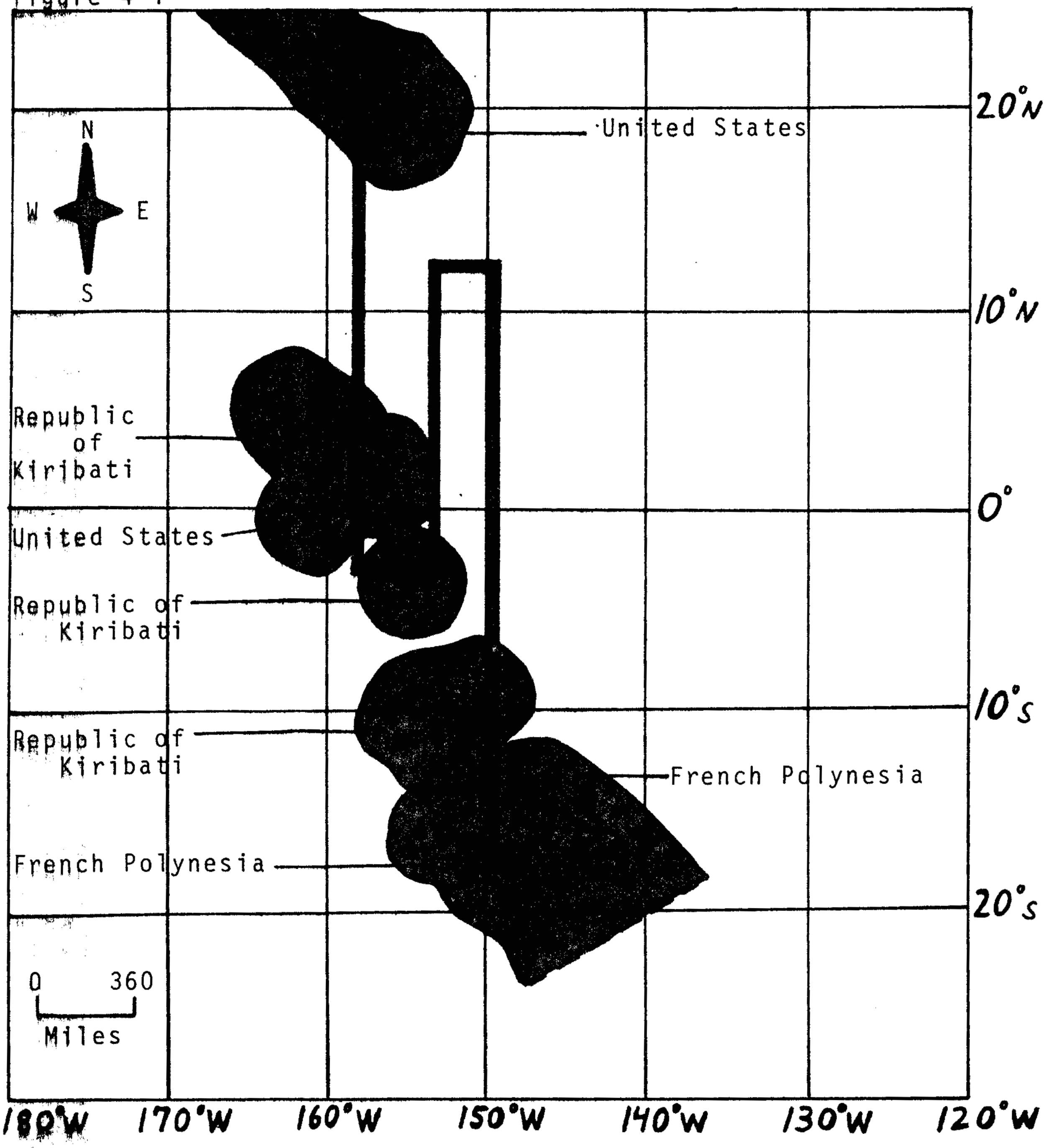
In both the political and cultural viewpoints,money and time were omitted from the discussion.The author believes that the views presented can not be defined in relation to money and time.What is being presented is an ideal that can not be priced or sacrificed.

The preservation of this nation is a must --- at any cost!Therefore the conclusion to be derived is that research must continue.Even though the economics of the period dictate another course,this country can not succomb to a small crisis that is only a relative thing.Optimism is a state of mind that must be maintained in such crisis.However in order to be optimistic,one must believe that this country will continue to exsist.In order for this nation to exsist,its ideals must be preserved.Research is part of those ideals --- therefore research is worthwhile.The political and cultural component override the economic component.The only thing economics will dictate is prudent use of the funds available.Whether the research is basic or applied has no bearing as both have a purpose in preserving the United States.Now that the question of research has been answered from a national standpoint,the implications it has on the rest of the world must be considered.

In deriving this answer,the Law of the Sea must be considered.The Law of the Sea Single Negotiating Text that was formulated at the Third Law of the Sea Conference at Geneva in 1975 is used as the basis for all legal precedents discussed in this report. Though the Single Negotiating Text was never ratified or accepted formally,many parts of it have become accepted as Common Law and are respected as such by most nations.The United States has conformed with most of the accepted Common Law parts of the Single Negotiating Text and adheres to the articles set forth.

The NORPAX/FGGE project can in no way be misinterpreted by a coastal nation as an attempt to exploit their resources.Before continuing,the coastal nations whose waters the NORPAX/FGGE eperiment did enter should be defined.The NORPAX/FGGE project entered waters under the sovereignty of France and Kiribati.The author defines sovereign waters as waters extending from the coastal nation's baseline out to 200 miles.The basis for the author's definition is the Exclusive Economic Zone and Continental Shelf concept set forth in the Single Negotiating Text. Coastal nations have all rights and sovereignty over waters extending 200 miles outward in terms of resource rights and exploitation. This concept has become accepted as Common Law by most nations though it was not ratified at the Third Law of the Sea Conference. Figure 4-1 depicts the courseline of the NORPAX/FGGE

Figure 4-1



project and all the coastal nations involved. Figure 4-2 below is a close-up depiction of all the islands of French Polynesia whose waters were entered by the research vessel while conducting the NORPAX/FGGE project. Figure 4-3, on the following page, is a

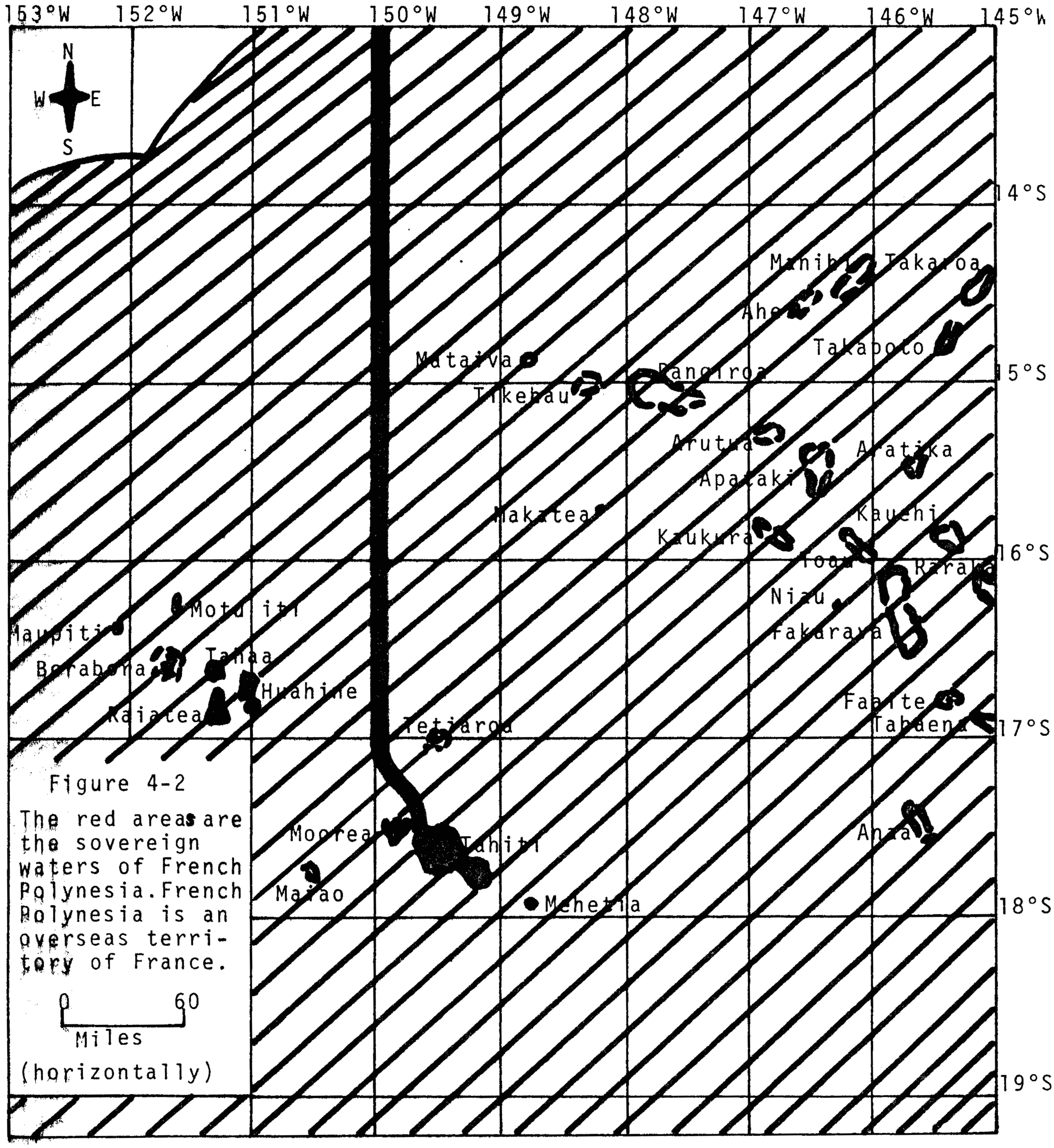


Figure 4-2

The red areas are the sovereign waters of French Polynesia. French Polynesia is an overseas territory of France.

close-up depiction of the northern Line Islands which compose part of the Republic of Kiribati and whose waters were entered by the research vessel while conducting the NORPAX/FGGE project.Figure 4-4 on the following page is a close-up of the southern Line

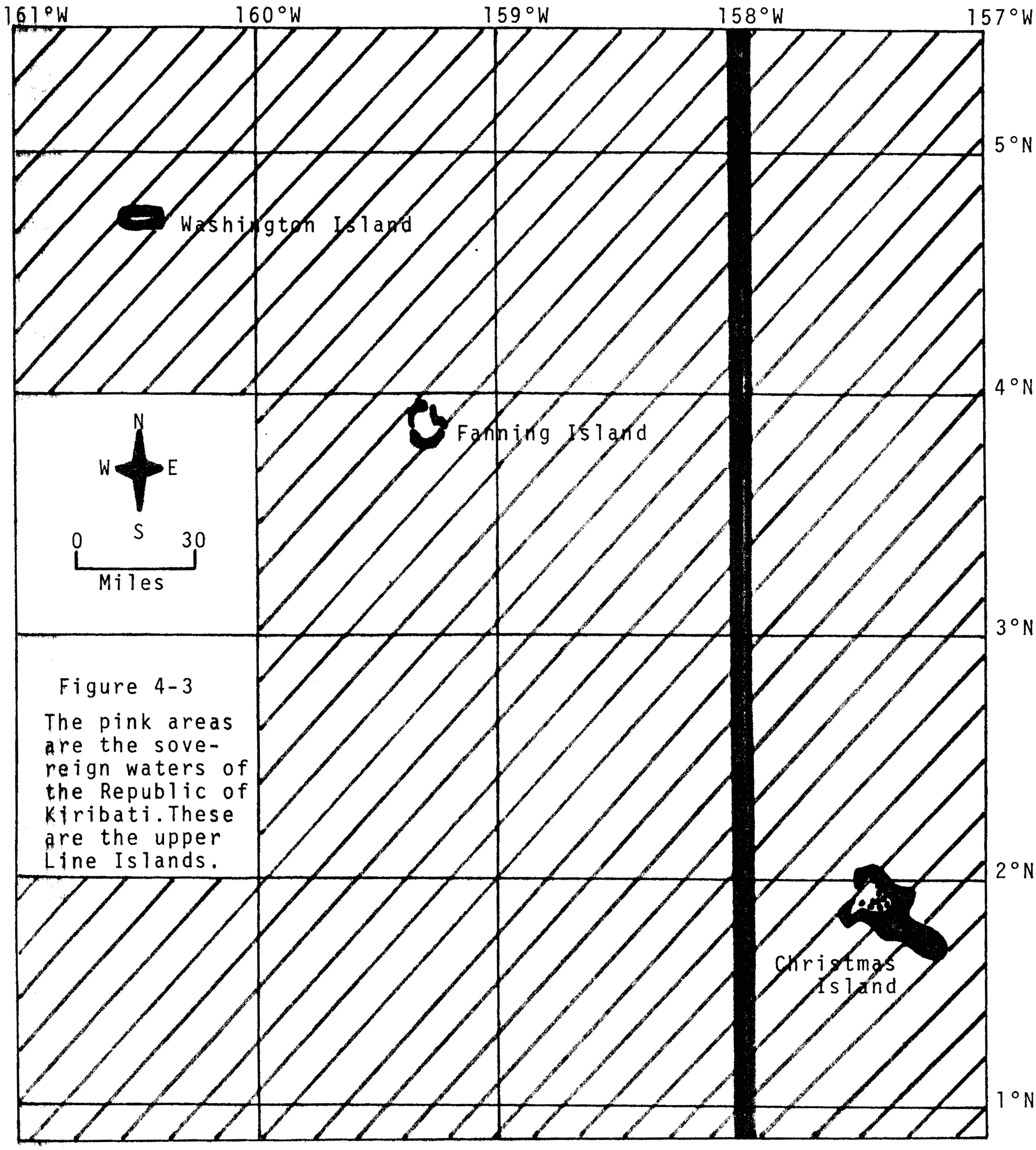


Figure 4-3

The pink areas are the sovereign waters of the Republic of Kiribati.These are the upper Line Islands.

Islands which also compose part of the Republic of Kiribati and whose waters were entered by the research vessel while conducting the NORPAX/FGGE project.Just as a note of reference,the Line Islands are one of several island chains that collectively compose the Republic of Kiribati.The Line Islands are the easternmost extent of the republic.

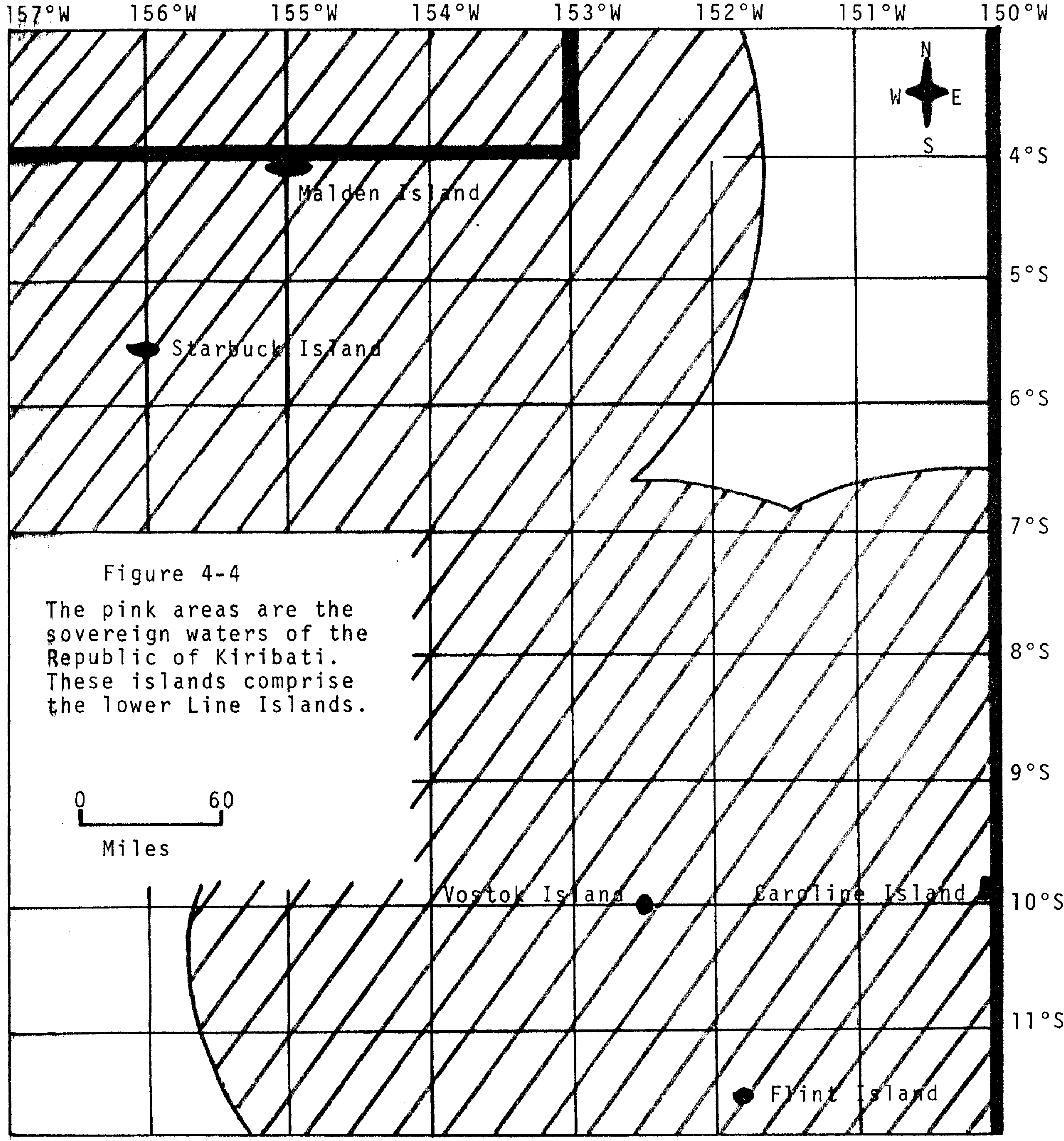


Figure 4-4
The pink areas are the sovereign waters of the Republic of Kiribati. These islands comprise the lower Line Islands.

The NORPAX/FGGE project can not be misinterpreted by either coastal nation as an attempt to exploit their resources or design of such notion since the project in no way promoted such desire and it conformed with the Common Law parts of the Single Negotiating Text.

The first argument of defense is the fact that the NORPAX/FGGE project was not taking any living or nonliving resources from either coastal nation's waters.The Single Negotiating Text states that within 200 miles of a coastal nation,nothing can be removed from the water or seabed unless permitted by the coastal nation.Specific reference is made to Article 16,paragraph 3 of the First Committee's Text on the Accommodation's of Activities in the Area and in the Marine Environment;Articles 45,46,and 49 of the Second Committee's Text on the Exclusive Economic Zone;Articles 62,63,and 71 of the Second Committee's Text on the Continental Shelf;Article 21 of the Third Committee's Text on Marine Scientific Research.Since nothing is being taken,the NORPAX/FGGE project does not violate any nation's rights.

The second argument of defense is that the NORPAX/FGGE project did seek permission from the coastal nations involved to do the experiment (parts of it) within their waters and permission was granted.This action complied with Article 5 and Article 14 of the Third Committee's Text on Marine Scientific Research.In addition,a full set of descriptive details as specified in Article 15 of the Third Committee's Text on Marine Scientific Research was provided to the coastal nations involved.

The third argument of defense is the nature of the project.The NORPAX/FGGE project is a research project of a fundamental nature that has no relation to the resources of the coastal nation's waters that were entered.Another way of looking at it is that the NORPAX/FGGE project is a basic research project as opposed to an applied research project.Article 18,paragraph 1 of the Third Committee's Text on Marine Scientific Research states that the distinction between fundamental and resource-related research must be made and communicated to the coastal nation whose waters the research project will be entering.Since this article was complied with and the research project is of a fundamental nature,none of the coastal nations involved have had their rights violated.

The last argument to be offered is that the United States is complying with the concept of international cooperation and is making the data available to all.(The NORPAX/FGGE project had scientists from other nations participating in the experiment.) The Single Negotiating Text that was formulated at the Third Law of the Sea Conference contains many articles fostering the concept of cooperation between countries.

All the arguments given by the author support the statement that the NORPAX/FGGE project can in no way be misinterpreted as a design to exploit a coastal nation's resources.The author would also like to remind the reader that the Single Negotiating Text which was formulated at the Third Law of the Sea Conference is not valid as a legal document since it was never agreed upon.But,many parts of it have become Common Law and they must be respected.

The only aspect of the NORPAX/FGGE project that the author would question from the viewpoint of international harmony and peace (though from a nationalistic point of view,the author has no qualms) is the submarine warfare data being collected in the experiment.This data was collected all the time (every half degree of latitude) including inside the 200 mile sovereign waters (as defined according to the articles on the Exclusive Economic Zone and the Continental Shelf) of the coastal nations involved. Article 4 of the Third Committee's Text on Marine Scientific Research stipulates that research is exclusively conducted for peaceful purposes.Submarine warfare can hardly be considered a peaceful purpose.However it is undoubtably a fact that irregardless of whether France or Kiribati are aware of the data being collected for submarine warfare, they are allies of the United States and support the American position of defender of the western world.Therefore whatever the United States does militarily,is supportive of their position as well.

Research has been severely curtailed today due to the Common Law acceptance of the Single Negotiating Text that was formulated at the Third Law of the Sea conference. Should the Single Negotiating Text ever be ratified or fully accepted as Common Law, the bureaucracy of initiating and conducting marine research would be overwhelming as well as frustrating.This would dissuade many scientists and researchers from enthusiastically doing research.Some would undoubtably not even be interested at all.

The intent of the Third Law of the Sea Conference's Single Negotiating Text is well meant but the practical aspect of carrying out the text as formal law is unrealistic. Today,every individual as well as nation has their own point of view and way of interpreting things.With the many different political,social,and economic structures existent in the world,there is bound to be confusion,misinterpretation,and outright conflict over any such document.The fact that the Third Law of the Sea Conference's Single Negotiating Text could not be ratified or agreed upon in 1975 exemplifies the author's viewpoint.

It is the author's viewpoint that the Single Negotiating Text that was formulated at the Third Law of the Sea Conference ought to be canned (disregarded).The Single Negotiating Text merely imposes harsh restrictions on marine scientific research.From the standpoint of research,there should be no Law of the Sea document.As long as every nation knows the boundaries of the other and respects them,there are no problems.If there are problems,go to the International Court or fight it out.

The first item of the Single Negotiating Text that is detrimental to marine research in general is the proposal for an international agency that oversees all research even on the high seas.Having such an agency would merely create another bureaucratic red tape organization which would be just as ineffectual as the United Nations.This agency would be comprised of representatives from different nations who would supposedly work together.With all the different radical nations there are,the author does not see how such an agency could function properly,objectively,or fairly.

The author also feels that the construction of such an agency destroys the concept of "high seas".The high seas are meant to be free of any jurisdiction.The "high seas" concept is one of the last vestiges of totally free places.They should be preserved for that reason alone!

The second detrimental item is the "International Seabed Authority" that is proposed in the Third Law of the Sea Conference's Single Negotiating Text.Whether this is an extension of the above unnamed agency or a seperate organization is not explained in the Single Negotiating Text.The "International Seabed Authority" would have the right to regulate all bottom sampling and resource removal from the sea floor.Knowing the position of many of the countries of the world in relationship to the United States as the author does only serves to strengthen the author's viewpoint that such an organization would be dangerous.The United States would get screwed no matter how you look at it.

The author feels that whoever has the capability and the interest in taking the resources and whatnot that are located in the high seas seabed is entitled to do so without hindrance or regulation by anyone.

A third detrimental aspect of the Third Law of the Sea Conference's Single Negotiating Text is the new zones that have been defined and their limits.Particularly the the Exclusive Economic Zone and Continental Shelf Zone that are proposed.(Both the Exclusive Economic Zone and Continental Shelf Zone are accepted as Common Law.) With the new zones,research is now subjected to the whims and regulations of the coastal nation whose waters they are in.Both of these zones extend 200 miles seaward from the coastal nation's baselines.Many of the interesting and important research areas are located within the boundaries of the Exclusive Economic Zone and Continental Shelf Zone.Should the coastal nation whose waters the research project is being conducted be hostile or in an anti-social state,it can misinterpret the Law of the Sea text so that it can terminate the other nation's research operations.Supposedly this should not happen but the Third Law of the Sea Conference's Single Negotiating Text is sufficiently ambiguous so that it can.

One final detrimental aspect of the Third Law of the Sea Conference's Single Negotiating Text is the ambiguity of the document itself.This has already been suggested in some of the prior items and viewpoints.The whole text is a potpourri of vague definitions and contradictory statements that can be read any way an individual wishes to read them.

One of the best examples of contradiction is the subject of the "International Seabed Authority".In the Single Negotiating Text of the Third Law of the Sea Conference,the First Committee and Third Committee contradict each other.The First Committee states that any country or international organization has the right to conduct marine scientific research on the high seas as long as they conform with the provisions of the international agency set up to monitor such activity.

The Third Committee states that any country or international organization can conduct marine scientific research on the high seas.There is no governing body to monitor the research.

An excellent example of the vagueness of the Third Law of the Sea Conference's Single Negotiating Text is the definitions of research of a fundamental nature and research of a resource-related aspect.The term resource-related is vague in the text and therefore could be interpreted differently by different nations.Naturally if the situation arose, both nations would have dispute settlement procedures initiated.This of course sounds fine but it is unfortunately not!The part of the Single Negotiating Text that deals with settlements of disputes is itself vague.The "Settlement of Disputes" section of the text does not define whether there will be a comprehensive dispute settlement mechnism or individual issue settlement process.In addition the proposed dispute settlement process has no criteria with which a distinction between fundamental research and resource-related research can be made.Lastly it has not even been determined what type of body should be handling such cases.

The conclusion to be drawn is that the Single Negotiating Text as derived at the Third Law of the Sea Conference in Geneva is highly useless as a document for prescribing rules of conduct for marine scientific research.

Research is an important part of the United States that must be carried on irregardless of the Law of the Sea issue.The proper atitude to be adopted by the United States in lieu of no formal international agreement is one of exercising prudent moral behavior in areas not covered by Common Law or other formal doctrines.

The NORPAX/FGGE experiment was a worthwhile project that did not violate any of the Common Laws that have been adapted from the Single Negotiating Text of the Third Law of the Sea Conference.In addition,it may be safely said that,the NORPAX/FGGE experiment was not an attempt by the United States to exploit the resources of either France or Kiribati.

Neither can it be interpreted any differently.

V

Honolulu and Papeete: A Comparison of Two Cities.

Honolulu and Papeete are climatically and geographically the same.However the similarities end there.From the social and economic viewpoints,Honolulu and Papeete are very different.Politically,Honolulu and Papeete are also different but the differences do not have a major impact in defining the two cities.The similarities and differences between Honolulu and Papeete will be examined from the viewpoint of Papeete's ability to become a major tourist attraction on the level of Honolulu.It must be noted that at this time (today) Papeete is a minor tourist center.It is also the author's belief that for a long time to come in the future,Papeete will remain a minor tourist center.

Climatically,both Honolulu and Papeete have the same weather.Honolulu is situated within the northern hemisphere's tradewind field which is known as the Northeast Tradewinds,Papeete is situated in the southern hemisphere's counterpart to the Northeast Tradewinds which is the Southeast Tradewinds.Both tradewinds are warm blowing winds that provide gentle breezes on otherwise warm areas.

Both cities are tropical due to their location near the equatorial regions of the Earth,Both cities are therefore subjected to strong solar radiation.

Temperatures for both Honolulu and Papeete are nearly identical (Papeete is slightly warmer).The temperature range between day and night as well as between seasons is also very similar.However it must be noted that the seasons are reversed between the cities. This is due to Honolulu being located in the northern hemisphere and Papeete being located in the southern hemisphere.Therefore when it is summer in Honolulu,it is winter in Papeete.

Due to both cities being located on the leeward side of their respective islands,the rainfall for both is similar.

Honolulu is located on the southern side of the island of Oahu and is protected from the strong force of the Northeast Tradewinds by the Koolau mountains.This is because the

Koolau mountains reach heights of 3,000 feet or more and interfere with the tradewinds and low clouds.The clouds buildup on the windward side of the mountains and drop most of their rain on that side.The leeward side is only subjected to the rain clouds that do manage to creep over the mountains,or the Kona weather system that develops with loss of the tradewinds.

Papeete is located on the northwestern side of the island of Tahiti and is protected from the strong force of the Southeast Tradewinds by a central mountain range composed of Mt. Ivirairai,Mt. Aorai,Mt. Orohena,and Mt. Tetufera.Because these mountains reach heights of 6,000 to 7,000 feet in elevation,they obstruct the Southeast Tradewinds and low clouds from passing over Papeete.The clouds buildup over the windward side of Tahiti and deposit most of the rainfall there.The little rainfall that Papeete does receive is from clouds that manage to creep over the mountains or a "Kona type" weather system that develops with loss of the tradewinds.However,in the case of Papeete's "Kona type" weather system,there is no volcano involved.

Another climatical factor that enhances both cities is the warm ocean waters surrounding the islands.In both cases,the typical sea surface temperature is approximately 27 degrees Celsius (Papeete is slightly higher).These warm temperatures of the water tend to exsist most of the year.Variation of temperature is slight.Having such a stable warm water mass around the islands helps to maintain a stable climate over the respective cities.Both the land temperatures and land breezes are regulated by the ocean waters and since the ocean waters are warm and stable,the climate is accordingly similar.

Due to both Honolulu and Papeete being located on the leeward sides of the respective islands of Oahu and Tahiti which are located in the tropical region of the Earth,both cities have desirable climates that make them attractive as vacation spots.

In terms of geography,Honolulu and Papeete are nearly mirror reflections of each other in opposite hemispheres.Both are located on islands that are part of archipelagoes in the Pacific Ocean.Figure 5-1 gives a cartographic depiction of the "mirror" concept.

Honolulu is located at 21 degrees,19.0 minutes North and 157 degrees,52.0 minutes West on the island of Oahu.Oahu is one of several islands that make up the Hawaiian

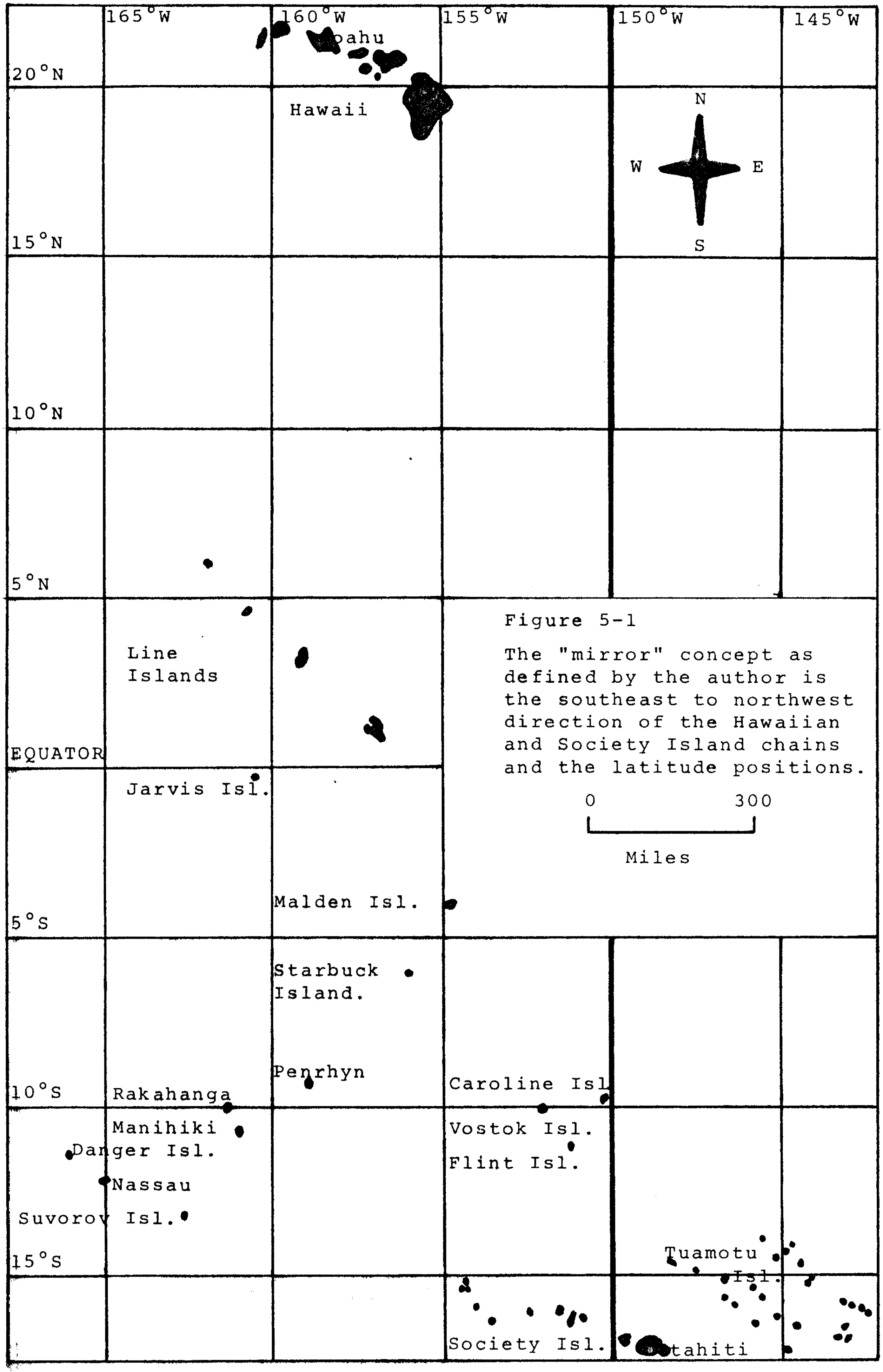


Figure 5-1

The "mirror" concept as defined by the author is the southeast to northwest direction of the Hawaiian and Society Island chains and the latitude positions.

Archipelago.All the Hawaiian Islands are volcanic in origin and are structured accordingly.All the islands originated from a hotspot in the Earth's mantle that is positioned at approximately 19 degrees North and 155 degrees,30.0 minutes West.These coordinates place the hotspot under the island of Hawaii.The archipelgo then extends northwest from the hotspot.The reason for this direction of the island chain is the movement of the Pacific plate (plate tetonics theory) to the northwest.As one proceeds up the island chain each island is older due to the further distance it is from the hotspot.At one time each of the islands were located exactly where the hotspot is but the movement of the Pacific plate shifted them to their present position.Figure 5-2

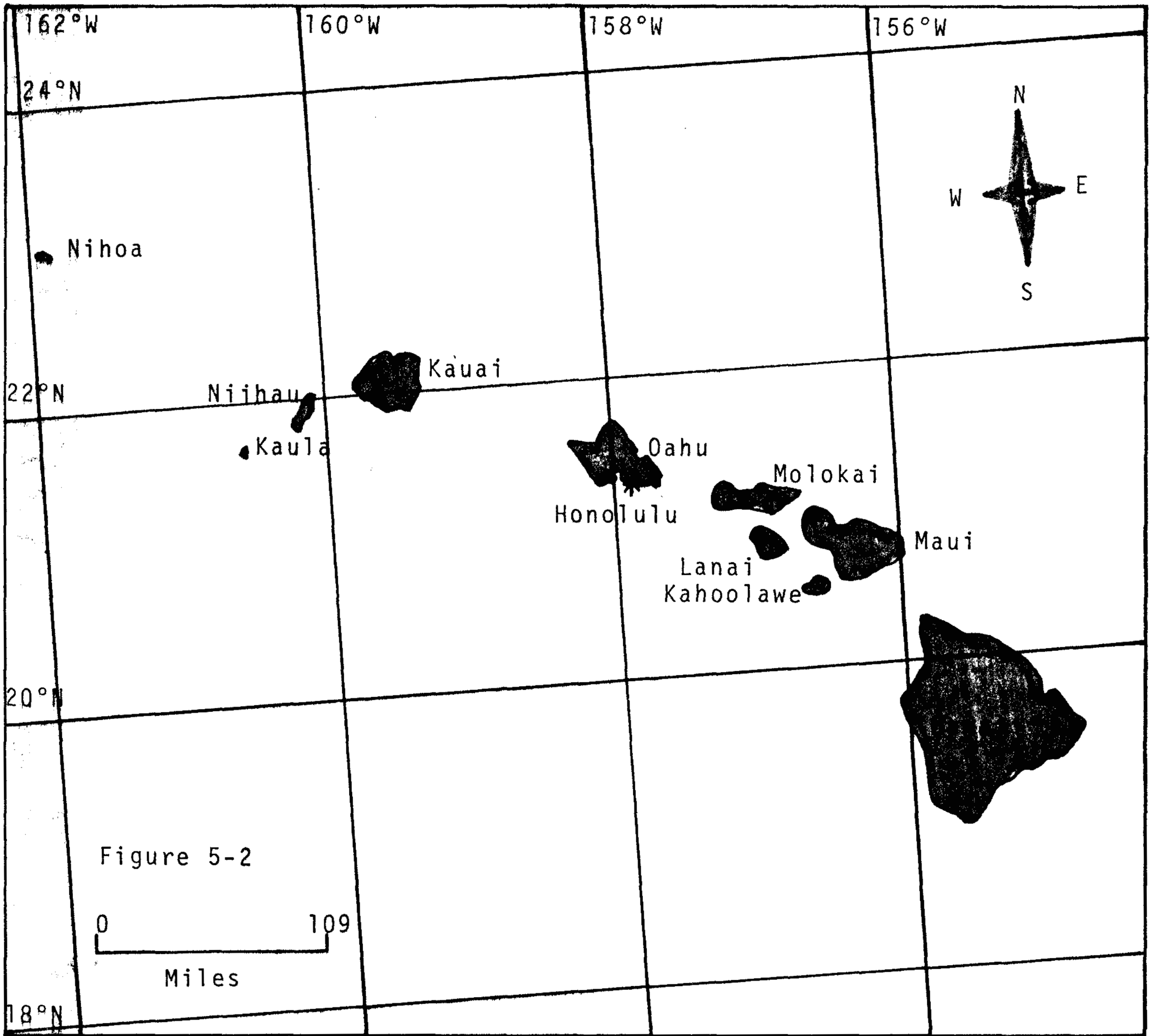


Figure 5-2

depicts the Hawaiian Archipelago and location of Honolulu.

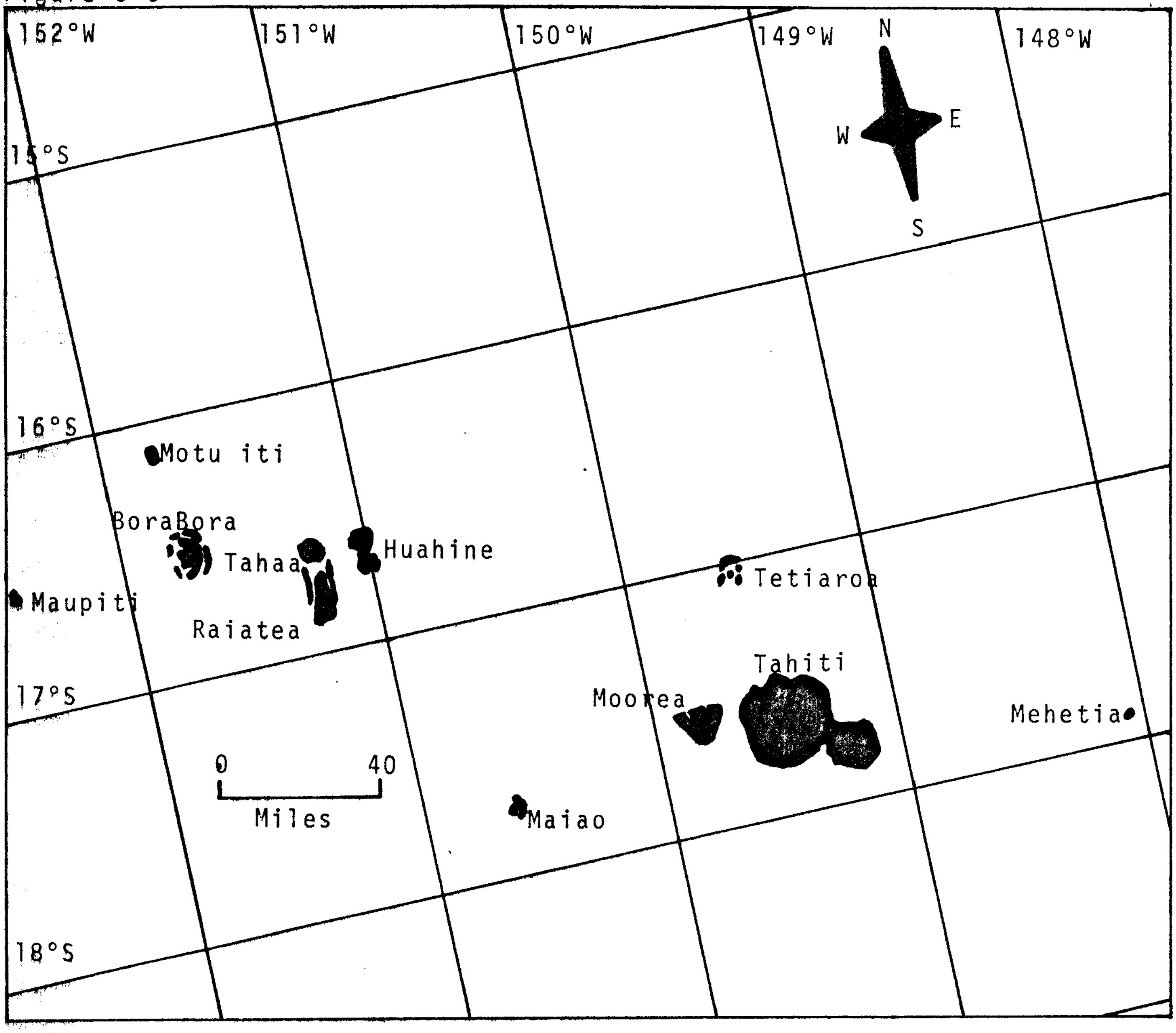
Papeete is located at 17 degrees,30.0 minutes South and 149 degrees, 36.0 minutes West on the island of Tahiti.Tahiti is one of several islands that make up the Society Island chain.All the Society Islands are volcanic in origin and are structured accordingly.Like the Hawaiian Archipelago,the Society Islands were created from a hotspot in the Earth's mantle that is positioned at approximately 17 degrees,53.0 minutes South and 148 degrees,40.0 minutes West.These coordinates place the hotspot under the island of Meheita.Unlike the Hawaiian Archipelago,the Society Islands appear to no longer have any volcanic activity.The Society Island chain extends northwest from the hotspot to the oldest above water island of Maupiti.The northwest direction of the island chain is due to the movement of the Pacific plate.The same phenomena that affected the formation of the Hawaiian Archipelago also affected the formation of the Society Island chain.As one proceeds up the Society Island chain each island is progressively older due to its further distance from the hotspot.As in the case of the Hawaiian Islands,each of the Society Islands were at one time positioned over the hotspot but the movement of the Pacific plate has brought them to their present location.Figure 5-3,on the following page depicts the Society Island chain and Papeete.

Tahiti is the "big island" of the Society Island chain.Except for the islet of Meheita,Tahiti is the newest of the Society Islands just as Hawaii is the newest of the Hawaiian Islands.To make an analogy for the sake of being the devil's advocate,Raiatea of the Society Islands would be Oahu of the Hawaiian Archipelago.The emphasis of this analogy is support the geographic similarity of the Society Island chain to the Hawaiian Archipelago.It should be understood that the author is not implying that Raiatea and Oahu are exactly the same age or identical.

By now it should be clear that Honolulu and Papeete are not on the same respective island of each island chain.

Honolulu is on a smaller island of an older date while Papeete is on the biggest island of a newer date.However in terms of geography of both respective islands that the cities are located on,the cities are located in the most favorable place of each island.

Figure 5-3



Both are on the leeward sides of their respective islands.Figure 5-4 on the following page depicts Honolulu on the leeward side of Oahu.Figure 5-5 depicts Papeete on the leeward side of Tahiti.Both cities are therefore sheltered from the strong force of the tradewinds and frequent rainfalls of the windward side.

Undoubtably the first settlers (non-Polynesians of the 19th century) to the islands chose the leeward sides of Oahu and Tahiti for the very reason that they are the more pleasant sides.As the population grew by birth and immigration,the new populace also found the leeward sides more favorable and settled there as well.Soon large settlements had developed and as they continued to grow,cities were born.Hence you had the develop-

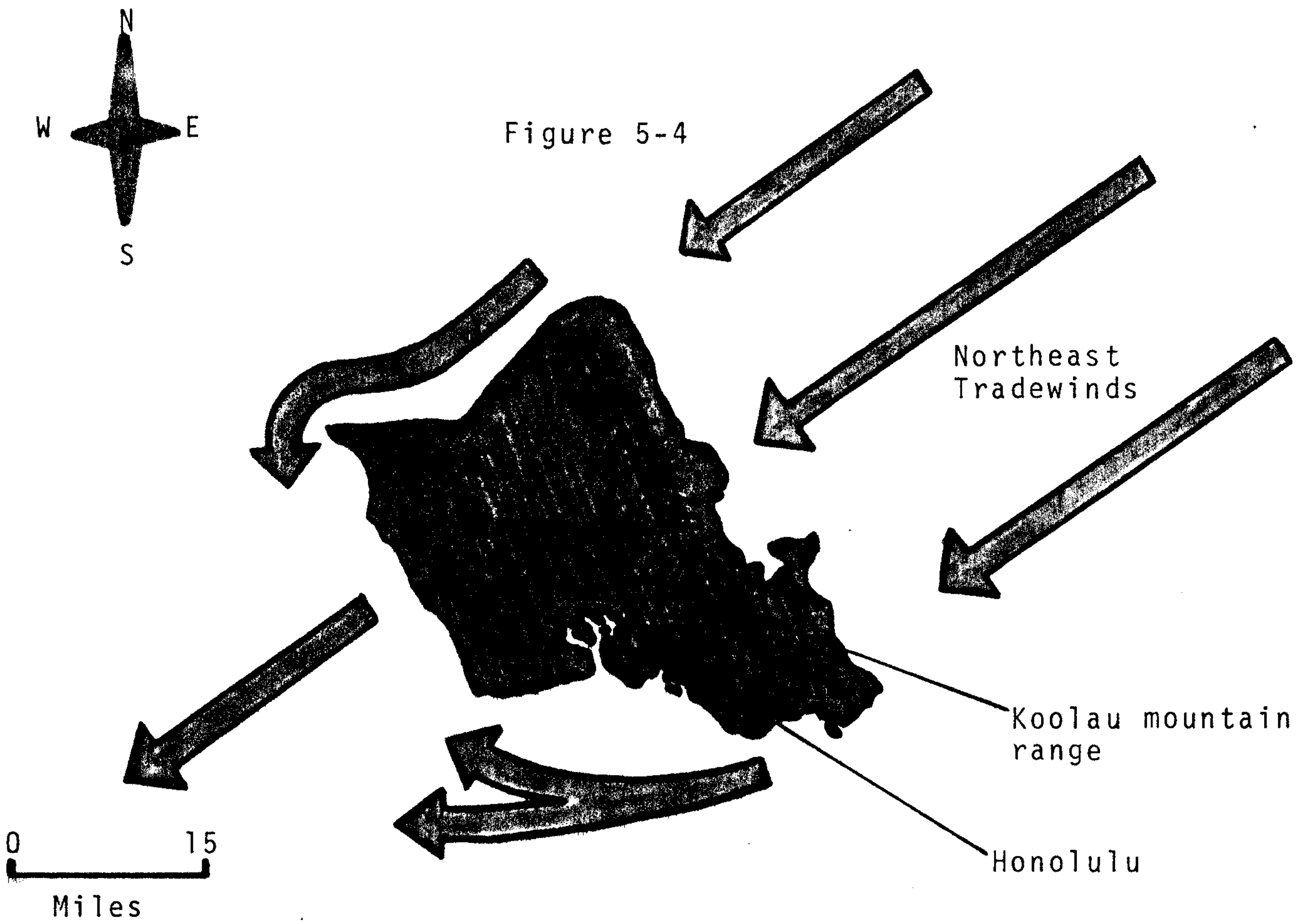


Figure 5-4

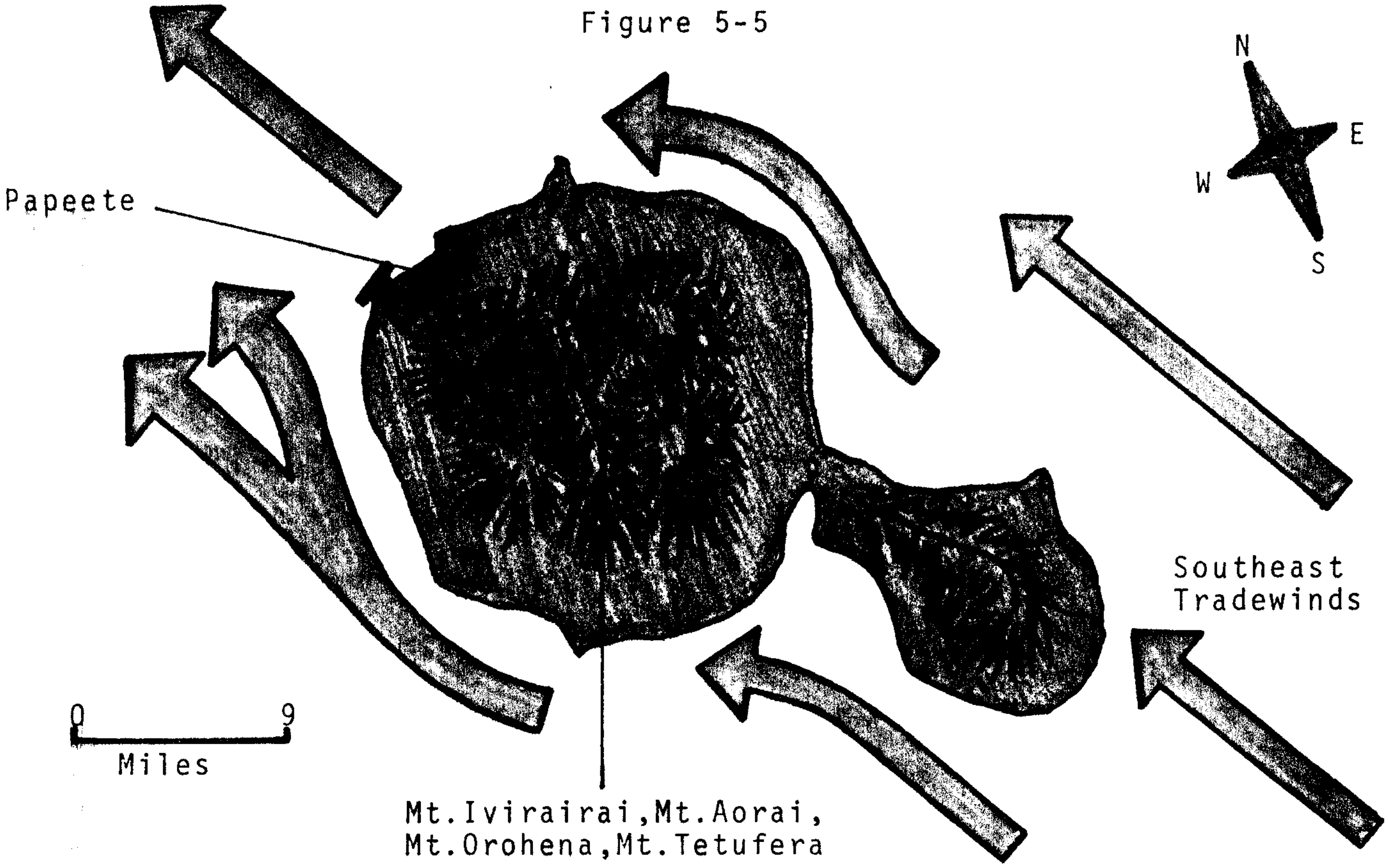


Figure 5-5

ment of the cities of Honolulu and Papeete.

However even though the geography of Honolulu and Papeete is very similar,it is also the reason why Honolulu has developed so much more than Papeete.

The majority of land mass on the Earth is located in the northern hemisphere.The majority of civilization is therefore also located in the northern hemisphere.All the fully developed nations of the world are located in the northern hemisphere.This combination of land mass,civilization,and developed nations makes the northern hemisphere a much more traveled part of the world.Since Honolulu is located in the northern hemisphere,it is a lot closer to the activity that occurs in the northern hemisphere.Honolulu is located in the travel lanes of activity that transpires between nations of the northern hemisphere.Due to Honolulu's attractive climate and geographical location,it tends to be a more heavily visited place.Naturally with an influx of people comes development.Being that Honolulu is a city within the United States,which is one of the more developed nations of the world,it is more strongly affected by progress and the concept of development.Honolulu has therefore become a modern city with big buildings, industrial complexes,transportation networks,et cetera.

Because of the modern amenities of Honolulu as well as climate and geographical proximity to the activity of the northern hemisphere,it is a much more easier city to visit.Tourism is therefore a much larger part of Honolulu's exsistence.People visiting Honolulu believe that at the same time that they are visiting an "exotic land" they still have all the "comforts" of home.This is of course quite true.

Papeete,on the other hand,is much further away from the heavily traveled northern hemisphere and therefore isolated.Papeete lacks the influx of people and development. This is not to say that Papeete is not up with the modern times because that would be false.This simply says that the scale of development or progress of Papeete is not of a magnitude that can compare to Honolulu.Being that Papeete is much further removed from the activity of the northern hemisphere,the influx of people is less and the need for development is less.One can not build businesses (tourist or otherwise) if there are no people to support them.Also the importation of materials to carry out the development is unwarranted as there is no basis for it.The geographical location of Papeete on an island in the southern hemisphere has isolated it from the development fervor of the heavily active parts of the world.

From the social aspect,Papeete outstrips Honolulu by a wide margin.Papeete has a charm of friendliness that Honolulu can not offer though it tries to.

The isolation of Papeete from the world has helped preserve its true Polynesian atmosphere and spirit of life.This is reflected in the people of Papeete.Papeete does not have the many different ethnic groups that Honolulu has.Therefore the competition between ethnic groups is not intense and the harsh anti-social relationships between ethnic groups is virtually non-exsistent.Anytime that there is strong competition between ethnic groups,there is conflict which can not helped but be noticed.In the case of Honolulu,it is exsistent and does get noted by the visiting observer (tourist).In Honoulu,a facade of "aloha spirit" is maintained so as to keep the tourist happy but, in the author's opinion,it is beginning to wear thin.

In the case of Papeete,the people are naturally congenial and friendly.This is because there is no conflict between ethnic groups which can create anti-social feelings. The people will smile at you,say hello to you,and help you.The author received assistance on matters without even inquiring about them.Basically the local people are intriqued by the visiting strangers who come from lands that they have only heard about. Another factor that gives Papeete the edge on social aspects is the lack of development of the city.The city has not been turned into a maze of stores,restaurants,and tourist attractions.

The people of Tahiti do not feel ousted from their world.Outsiders have not taken over their world and turned it into a big tourist center.The main street (Boulevard Pomare) for example has not been turned into an alley of fancy tourist shops but it is rather an avenue of mixed stores ranging from car dealers and toilets to clothing shops and luxury items.

A final factor is the Polynesian ethnicity of the people of Papeete.The Polynesians have generally been recognized as a friendly group of people that relate to others with warmness.Even though there has been some mixing of races (mostly Caucasian and Polynesian),the Polynesian social traits are apparently retained.This factor which the author calls the "true aloha spirit" is still exsistent and spread by the people of Papeete.

Due to the overwhelming warmness of the inhabitants of Papeete as compared to Honolulu,the tourists would feel more welcome.Not only that,but the tourists would feel more relaxed since they would not feel that they were being "taken".The author has run into many tourists in Honolulu who feel that they have been "taken".Basically the only reason they feel as such is because the warm "aloha spirit" is not there. Tourists realize that they have to spend money if they come to Honolulu.If the locals (all people of the the tourist related businesses) would be more friendly in their transactions with the tourists,the tourists would go away feeling a little more happy.

Papeete by far exceeds Honolulu in providing a warm social atmosphere and "true aloha spirit".However from the viewpoint of social activities to entertain the tourists for the duration of their visit,Honolulu by far exceeds Papeete.

Honolulu provides a multitude of entertainment places ranging from discoteques, niteclubs,luau festivities,restaurants to scenic cruises,Hawaiiana shows,points of interest,and whatever else one can think of to do.

The choice of type of music,what kind of food,and what interests the individual is endless (in terms of the average length of stay of the tourist).Honolulu,during the day, offers plenty of places to visit and things to do.Honolulu has one of the biggest shopping centers (Ala Moana shopping center) in the world with all sorts of stores.Places of interest for the tourists include the Kodak Hula show which depicts actual Hawaiian dances and culture;Waikiki Aquarium which has one of the best as well as some of the only fish collections in the world;Paradise Park which depicts many of the tropical flowers and plants found in the tropics;Foster Botanical Gardens which also features many of the lush tropical plants and agricultural items;Waikiki beach and Ala Moana beach which are easily reached;the Punchbowl Monument and Arizona Memorial which many people wish to visit for purposes of remembering one of the great atrocities of the

20th century;sports fishing facilities;diving equipment facilities as well as good diving locations;and finally a means of being able to visit all these places.There are of course more places to visit and things to do than is mentioned here but the point is made.

Not only does Honolulu have many interesting places and social activities but the island (Oahu)itself has many interesting places to visit and activities going on.Examples are Waimea Beach Park,the Polynesian Cultural Center,and Sea Life Park.Since almost all the hotels are in Honolulu,people have to come to Honolulu and stay there. They then go out and visit these different outside places and activities.

Honolulu has the added advantage of a good transportation network that links all the different places and social activities.Honolulu's bus system is an excellent modern system that is comfortable and efficient.In addition there are many private bus systems that help tourists get to the many places and activities.There are plenty of taxis available for getting around within the city for those who prefer taxis.There are also plenty of automobile rental agencies that provide good clean cars for people interested in touring the sights on their own.If an individual prefers motorcycles,mopeds,or bicycles,they are also available.The road system is well defined and in good condition so there is little trouble getting around.

Due to the many social activities,places of interest,and excellent transportation facilities,Honolulu is well prepared for entertaining the tourist.Papeete,on the other hand,is not.

Papeete is very similar to the Latin or South American cities that are of little size and are in the tropics.It does not have much color or attractiveness for the tourist.The main avenue (Boulevard Pomare) is nicely lined with trees and decent looking buildings but one block up from the main avenue provides a total change.Some areas would remind an individual of a slum district.There is even an industrial center within the heart of the city that makes plenty of noise.

Papeete does not have any decent beaches at all.One must leave the city to find a decent beach.There are no cultural or ethnic oriented social activities that the tourist may visit or participate in.(From time to time there are some such events staged but not on a regular basis.)There are no beautiful gardens,museums,monouments,aquariums, or dive facilities in Papeete.If one wishes to go swimming,surfing,or diving they must leave the city.They must also have the equipment as Papeete is very limited in being able to provide such items.For those who enjoy looking at beautiful scenery,they must also leave the city and find it.Tahiti does have plenty of scenery and beautiful scenic spots but it is out in the country.For those who enjoy sports fishing,sport fishing outfits are available.Papeete has a few shops,many with excellent French imports,but that is it.

For nighttime activities,there are a few discoteques and restaurants but that is it. The city of Papeete is basically a dead town at night.One would have to occupy themselves in the evening.

The transportation system in Papeete is the infamous vehicle known as "Le Truck". These are the buses.They are basically flatbed trucks outfitted with benches on both sides of the flatbed and a roof.In addition they all provide disco music whether one likes it or not at a decibel that can make one deaf.(Disco fever is at a peak in Tahiti.)The ride can be hard on one's derrier since the benches are wooden and the shock absorbers are not too effective.It is however the local means of getting around and for those interested in seeing the local lifestyle,it is a good way of doing it.The time schedule is up to the driver.There are no private bus companies in Papeete.

There are a few automobile rental agencies as well as moped and bicycle rental agencies.The roads are decent but due to the lack of things to do,there is not much value to renting the vehicles except for going around the island of Tahiti once or twice.

Papeete is basically not good for anyone who is looking for things to do or participate in.Tourists would rather stay at a hotel outside of Papeete or on another island. Most hotels are in fact outside Papeete and are self-sufficient units that attempt to provide all the entertainment for the tourists within the complex.

For people wishing to get away from it all,Papeete is not a bad place to visit.Also for those people who enjoy scenery and picturesque settings (romantic and exotic),Tahiti is a beautiful place to visit though Papeete is not an example of it.

Because of Papeete's lack of social activities and places to visit,it is not a big tourist attraction.Therefore in comparison to Honolulu,Honolulu is the more popular city to visit.Honolulu,in addition,has the added attraction of the other Hawaiian Islands which are beautiful and do attract visitors.These visitors must however come to Honolulu first before going on to another island.Therefore Honolulu is the focal point of all activities in the Hawaiian Archipelago.Papeete can not compare to Honolulu in terms of social activities and entertainment for the tourists.Papeete is just not prepared for being a tourist center.

Economically,Papeete can not compare to Honolulu either.The geographic location not only set Papeete out of the more heavily traveled areas of the northern hemishere but also made the transportation costs of reaching Papeete much more expensive.Papeete is a very expensive city to reach from almost any part of the globe.The average tourist can not afford the cost of traveling to and from Papeete let alone the costs of staying there.

Papeete is a very expensive town for the tourist who is not prepared for it.There are of course reasonable (the author bases the term reasonable as it is defined by American standards) places in Papeete but the tourists are unaware of them until they have arrived,and by that time they are committed to the arrangements made.For the tourist visiting Papeete for the first time,there is basically no way he/she can know about the more reasonable places until they get there.This is because the reasonable places do not advertise abroad the way the big outfits do.It should be noted that the reasonable places do not have all the plush accommodations that the big outfits do but they are still adequately furnished.It is also a fact that if these reasonable places did advertise in a travel brochure or whatnot,they would not sound appealing or as appealing as one of the big places.

A second expensive factor is food since most of it is imported from abroad.Most restaurants charge high prices when compared to prices in Honolulu.There is of course a more reasonable aspect to dining in Papeete but it is undoubtably something the tourist would not wish to do every evening.The reference to reasonable meals is the dinner wagons that come down to the harbor front in the evening.The dinner wagons,which total about thirtyfive altogether,set up benches around the rear of the vehicle and then cook and serve meals.The selection is quite varied and the meals are very good. A steak dinner can be had for approximately four dollars (U.S. dollars).

Most souvenir shops,boutiques,clothing stores,and other retailers are very expensive in Papeete.An example to demonstrate the price differences between Honolulu and Papeete is the cost of shampoo in both cities.In Honolulu,a ten ounce bottle of basic shampoo (none of the fancy brands or expensive stores) costs approximately ninetynine (99) cents (1980-U.S. dollars).That same bottle of shampoo in Papeete costs six (6) dollars (1980-U.S. dollars).Another example is the price of razor blades (standard pack of five twinbladed razor blades) in both cities.In Papeete,the price is approximately four (4) dollars and sixty (60) cents.In Honolulu,the same razor blades cost one (1) dollar and ninetyseven (97) cents.

Papeete is simply not an economic city that can attract tourism the way Honolulu can.Honolulu is a much cheaper city to reach for the majority of tourists.This is of course due to the geographic location of Honolulu which places it a lot closer to the active regions of the world.

Honolulu is also much more reasonable in terms of accommodations.One important factor that makes it cheaper is the tour packages that can be offered.Since Honolulu is much closer to the active regions of the world and sources of tourists,and it has so many social activities,tour packages can be arranged on a large scale that are both reasonable and affordable by the tourist.

Food is also less expensive.The tourist can choose between fast food outlets,middle-priced restaurants,or high-priced dining places.The tourist sets the price on what he/she can afford.This option is not as readily available in Papeete.

The many different shops,boutiques,and department stores are also much more reasonable than their counterparts in Papeete.Honolulu is simply less expensive and more affordable by the tourist.

One point to be noted is that Papeete is trying to build up its economic base by providing investment incentives to certain foreign businesses.Among those being encouraged to invest in Papeete are tourism,agriculture,and fishing industries.Papeete has developed a special legal code known as the Investment Code which is used to entice foreign investors.The Investment Code offers benefits to investors such as corporate and individual tax suspensions for several years,repatriation of profits and capital without penalty,hotel investment premiums,and privileged fiscal systems.There are of course other incentives.However the point is made that Papeete (as well as the rest of French Polynesia) is actively seeking investors that can help build Papeete into a healthy developed city.

Honolulu is,on the other hand,trying to slow its growth so that it doesn't become overrun by too many people or businesses.Honolulu has developed a stringent set of legal regulations concerning business enterprises,buildings,and other development projects.These regulations must be complied with fully before businesses or development projects can be started.Among the examples of legal regulations that have been established are the Environmental Impact Statement which is needed before anything is started,the building permits which are needed before any structure can be started,the business permits which are needed before any business is initiated,and the zoning laws which establish what kinds of businesses or development projects may be initiated in a certain area.There are of course many other regulations but the point is made.Honolulu is at the stage where further growth and development has to be done slowly and carefully so that what is left of the natural environment is preserved.

Politically Honolulu and Papeete are different.Honolulu is a city in the state of Hawaii which is one of the federation of states that collectively compose the United States of America.

Papeete is a city in the Overseas Territory of French Polynesia which is a territorial possession of the Republic of France.The Overseas Territory of French Polynesia has all but autonomous government.

The official language of Honolulu is English.The official language of Papeete is

French and Tahitian.However the different political status and languages of the two cities do not hinder either city from effectively attracting tourists.Both Honolulu and Papeete are very similar in some political areas.

Both cities are the capitols of their respective political entities (state and overseas territory).Both cities are in the western world and subscribe to the concepts of democracy and liberty.Both cities have a mayor and city council to govern their political operation.Both cities have police and fire departments to provide the necessary emergency services.Both provide social services and public works.Neither Honolulu or Papeete has taxation (Honolulu is subjected to a state tax but this should not be confused as a city tax).Honolulu and Papeete both have uniform currencies (though of different nomenclature and value).Honolulu utilizes the American dollar.Papeete uses the French Pacific Franc.Both cities are the business centers of the respective political entities.Finally as a last note,both Honolulu and Papeete welcome tourists and other visitors to their cities.

Due to the many similar characteristics of Honolulu and Papeete,both cities are equitable political structures though of different political status.

In conclusion,both Honolulu and Papeete have similar qualities that make them attractive as tourist centers.However due to the geographical and economical advantage of Honolulu over Papeete,Honolulu will undoubtably remain the large tourist center it is while Papeete continues at its present level.For how long? Perhaps forever!

Appendix.

The appendix contains some of the actual data obtained from the different experiments described in chapter two.The appendix is meant to complement the text of chapter two by displaying some of the formats utilized for recording data.

The data printout below is a sample of an actual CTD station.

FGGE 15 WECOMA

CDT REPORT, STATION 25, CAST 1

S ROUTINE CORR FOR P AND T EFFECTS ON CERAMIC SENSOR, AND T48 CONV.

PRESS.	TEMP.	COND.	SAL.	OXY P	OXY T	O-2	RAW P	POT. T.
2459.4	18.022	1.794	0.502	99.990	1.920	0.392	2464.1	17.649
5.1	26.181	0.658	-0.346	62.567	26.752	19.000	6.6	26.180
ENTERED WATER: 10-JUN-80 02:15:54								
6.8	28.334	56.470	34.918	63.600	26.752	6.503	8.3	28.332
8.6	28.352	56.471	34.905	60.400	26.880	6.286	10.1	28.350
7.5	28.356	56.472	34.903	60.967	26.752	6.203	9.0	28.354
8.7	28.355	56.470	34.902	72.533	26.880	9.760	10.2	28.353
7.5	28.354	56.471	34.904	63.433	26.752	7.356	9.0	28.352
9.2	28.356	56.472	34.902	60.433	26.752	6.473	10.7	28.354
10.5	28.357	56.474	34.903	62.167	26.880	6.224	12.0	28.354
11.6	28.357	56.474	34.902	61.300	26.752	6.375	13.1	28.354
13.2	28.358	56.476	34.903	61.633	26.880	6.306	14.7	28.355
18.4	28.360	56.480	34.902	60.967	26.880	6.425	19.9	28.355
24.3	28.352	56.472	34.901	60.933	26.880	6.143	25.8	28.346
30.2	28.343	56.464	34.900	62.633	26.880	6.272	31.7	28.335
37.4	28.361	56.490	34.903	62.333	27.008	6.287	39.0	28.351
44.6	28.353	56.486	34.904	59.833	27.136	6.262	46.2	28.342
51.9	28.363	56.496	34.902	59.800	27.136	6.282	53.5	28.350
58.7	28.355	56.492	34.903	59.000	27.136	6.276	60.3	28.340
64.2	28.359	56.502	34.905	61.133	27.136	6.334	65.8	28.343
70.7	28.250	56.352	34.879	61.167	27.264	6.072	72.3	28.232
77.6	28.048	56.195	34.917	58.967	27.264	6.174	79.2	28.028
83.6	27.821	55.945	34.908	58.933	27.264	6.113	85.2	27.800
91.1	27.059	55.197	34.945	57.333	27.264	5.984	92.7	27.037
97.3	26.457	54.672	35.021	52.067	27.392	5.622	98.9	26.434
102.6	25.535	53.656	34.985	47.733	27.392	5.676	104.2	25.511
108.4	24.261	52.248	34.924	44.333	27.392	5.307	110.0	24.237
113.7	23.959	51.969	34.949	41.467	27.392	5.035	115.4	23.934
119.1	23.736	51.730	34.941	40.767	27.392	4.806	120.8	23.710
127.0	21.899	49.720	34.848	35.933	27.392	4.545	128.7	21.873
133.0	17.149	44.820	34.755	26.967	27.392	4.627	134.7	17.126
139.2	15.171	42.826	34.711	23.933	27.392	3.838	140.9	15.149
146.4	14.495	42.152	34.695	22.600	27.264	3.686	148.1	14.473
157.3	13.131	40.836	34.694	22.600	27.008	3.786	159.0	13.109
168.6	12.053	39.913	34.796	20.500	26.624	3.777	170.3	12.031
179.3	11.926	39.850	34.848	16.100	26.368	2.938	181.0	11.902
190.5	11.783	39.740	34.870	15.267	25.728	2.760	192.3	11.758
202.2	11.789	39.773	34.891	11.267	25.216	2.166	204.0	11.762

212.3	11.667	39.648	34.879	9.533	24.576	1.826	214.1	11.639
223.2	11.565	39.552	34.876	8.900	23.936	1.716	225.0	11.536
235.1	11.561	39.552	34.874	8.467	23.424	1.626	236.9	11.530
247.3	11.532	39.532	34.876	8.000	22.784	1.616	249.1	11.500
258.8	11.506	39.510	34.874	7.300	22.272	1.530	260.6	11.472
270.1	11.447	39.456	34.872	7.167	21.632	1.494	272.0	11.412
281.2	11.232	39.236	34.852	6.900	21.120	1.424	283.1	11.196
292.5	11.102	39.107	34.842	7.767	20.480	1.667	294.4	11.065
303.0	10.918	38.924	34.829	7.633	20.096	1.656	304.9	10.880
313.8	10.866	38.876	34.825	7.933	19.584	1.686	315.7	10.827
324.1	10.737	38.746	34.813	7.800	19.072	1.728	326.0	10.697
336.7	10.561	38.570	34.798	7.800	18.560	1.724	338.6	10.519
348.1	10.392	38.407	34.790	8.567	18.176	1.901	350.1	10.349
359.4	10.145	38.161	34.771	8.167	17.664	1.885	361.4	10.102
371.2	9.957	37.980	34.762	6.833	17.280	1.563	373.2	9.913
382.1	9.750	37.776	34.747	7.733	16.768	1.807	384.1	9.705
392.3	9.658	37.703	34.756	7.367	16.384	1.776	394.3	9.612
403.7	9.355	37.390	34.720	6.800	16.000	1.671	405.7	9.309
414.1	9.221	37.272	34.723	5.833	15.616	1.495	416.1	9.174
425.7	9.176	37.230	34.718	5.667	15.232	1.442	427.8	9.128
438.9	8.969	37.032	34.706	6.833	14.848	1.738	441.0	8.920
449.9	8.626	36.694	34.681	7.033	14.464	1.606	452.0	8.577
460.5	8.467	36.556	34.686	6.133	14.080	1.641	462.6	8.417
473.0	8.322	36.428	34.687	4.600	13.824	1.267	475.1	8.271
484.4	8.267	36.380	34.685	4.367	13.440	1.162	486.5	8.215
495.1	8.009	36.125	34.662	4.267	13.184	1.168	497.3	7.957
506.2	7.737	35.874	34.656	4.133	12.928	1.125	508.4	7.685
517.4	7.584	35.732	34.650	4.167	12.672	1.154	519.6	7.531
528.0	7.491	35.656	34.655	5.400	12.416	1.441	530.2	7.437
540.8	7.250	35.429	34.642	5.833	12.160	1.654	543.0	7.196
552.7	7.106	35.300	34.639	5.833	11.904	1.698	554.9	7.051
563.2	7.078	35.279	34.639	5.700	11.648	1.647	565.4	7.022
576.0	7.054	35.264	34.641	5.500	11.392	1.633	578.3	6.997
586.8	7.042	35.256	34.639	5.600	11.136	1.640	589.1	6.984
599.0	6.995	35.217	34.637	5.533	11.008	1.643	601.3	6.936
609.1	6.980	35.208	34.638	5.600	10.752	1.655	611.4	6.920
623.0	6.948	35.180	34.633	5.667	10.496	1.722	625.3	6.887
633.5	6.861	35.106	34.633	5.767	10.240	1.754	635.8	6.799
644.1	6.850	35.100	34.633	5.667	10.112	1.731	646.4	6.787
654.8	6.779	35.034	34.626	5.667	9.856	1.751	657.2	6.715
667.3	6.749	35.016	34.631	5.700	9.728	1.772	669.7	6.684
677.4	6.723	34.994	34.628	5.733	9.600	1.774	679.8	6.657
687.6	6.661	34.940	34.625	5.733	9.472	1.805	690.0	6.595
698.3	6.600	34.886	34.622	5.933	9.216	1.874	700.7	6.533
709.1	6.540	34.834	34.620	6.367	9.088	1.998	711.5	6.472
719.4	6.474	34.777	34.618	6.067	8.960	1.981	721.8	6.406
729.9	6.375	34.688	34.614	6.100	8.832	1.950	732.4	6.306
740.1	6.292	34.616	34.613	6.133	8.832	1.958	742.6	6.223
751.0	6.151	34.489	34.608	6.200	8.576	1.995	753.5	6.081
762.6	6.078	34.428	34.609	6.467	8.448	2.132	765.1	6.008
773.3	6.037	34.396	34.609	6.533	8.320	2.188	775.8	5.966
785.8	5.976	34.342	34.604	6.867	8.192	2.236	788.3	5.904
799.0	5.911	34.285	34.600	6.767	7.936	2.349	801.5	5.838
809.1	5.772	34.164	34.600	6.833	7.936	2.311	811.7	5.699
820.6	5.729	34.130	34.600	7.000	7.808	2.404	823.2	5.655
831.3	5.621	34.039	34.602	7.000	7.680	2.407	833.9	5.547
844.8	5.594	34.021	34.603	7.067	7.552	2.466	847.4	5.519
857.2	5.468	33.909	34.598	7.067	7.424	2.451	859.8	5.392

868.5	5.383	33.840	34.601	6.867	7.296	2.459	871.1	5.307
880.8	5.303	33.768	34.595	7.000	7.168	2.460	883.5	5.226
893.7	5.226	33.711	34.603	7.067	7.168	2.544	896.4	5.149
905.1	5.216	33.706	34.602	6.967	6.912	2.491	907.8	5.138
918.1	5.190	33.689	34.602	6.800	6.912	2.443	920.8	5.111
929.6	5.138	33.648	34.603	6.467	6.656	2.333	932.3	5.058
939.7	4.975	33.505	34.602	6.733	6.528	2.477	942.4	4.895
951.1	4.865	33.416	34.607	6.767	5.888	2.519	953.8	4.785
962.4	4.765	33.330	34.606	6.667	5.248	2.553	965.2	4.685
973.0	4.678	33.260	34.609	6.700	4.992	2.546	975.8	4.597
983.1	4.634	33.224	34.608	6.667	4.992	2.581	985.9	4.553
993.7	4.575	33.178	34.611	6.533	4.736	2.538	996.5	4.493
1003.8	4.529	33.143	34.613	6.400	4.352	2.487	1006.6	4.447
1014.8	4.469	33.096	34.615	6.267	4.352	2.443	1017.6	4.386
1013.5	4.467	33.094	34.615	6.233	4.096	2.449	1016.3	4.384

**** ROSETTE TRIP AT 10-JUN-80 02:47:30 AVERAGED RAW DATA:

	P	T	G	O2	TO2	
RAW DATA:	1017.0	4.466	33.094	6.206	4.171	12 PTS AVERAGED
STD. DEV:	1.1	0.0016	0.0010	0.0229	0.0631;	SALT= 34.615, O2= 2.455

1003.6	4.500	33.120	34.616	6.267	4.096	2.443	1006.4	4.418
992.7	4.542	33.150	34.613	6.267	4.096	2.466	995.5	4.461
981.9	4.600	33.196	34.612	6.400	4.096	2.509	984.7	4.519
971.2	4.644	33.230	34.611	6.600	4.224	2.546	974.0	4.564
959.9	4.744	33.314	34.610	6.567	4.224	2.556	962.7	4.664
949.3	4.852	33.404	34.608	6.533	4.352	2.510	952.0	4.772
938.5	4.927	33.464	34.605	6.600	4.352	2.529	941.2	4.848
927.5	5.116	33.629	34.605	6.500	4.352	2.460	930.2	5.036
917.0	5.178	33.680	34.605	6.167	4.352	2.540	919.7	5.099
904.5	5.214	33.705	34.603	6.267	4.480	2.329	907.2	5.136
893.1	5.221	33.708	34.605	6.500	4.480	2.409	895.8	5.144
882.8	5.248	33.730	34.607	6.567	4.480	2.427	885.5	5.171
871.1	5.354	33.816	34.602	6.700	4.480	2.463	873.7	5.278
860.5	5.414	33.873	34.611	6.567	4.480	2.415	863.1	5.338
849.6	5.555	33.988	34.603	6.567	4.480	2.395	852.2	5.480
837.6	5.598	34.022	34.603	6.600	4.480	2.383	840.2	5.523
825.0	5.636	34.052	34.604	6.567	4.480	2.377	827.6	5.562
813.8	5.749	34.151	34.607	6.567	4.608	2.373	816.4	5.676
802.1	5.877	34.257	34.601	6.533	4.608	2.343	804.7	5.804
791.0	5.962	34.332	34.605	6.400	4.608	2.284	793.5	5.890
779.1	5.986	34.350	34.606	6.433	4.736	2.265	781.6	5.915
767.9	6.056	34.412	34.610	6.300	4.608	2.238	770.4	5.985
757.7	6.106	34.455	34.613	6.100	4.736	2.155	760.2	6.036
746.6	6.199	34.536	34.614	5.967	4.736	2.089	749.1	6.129
736.1	6.297	34.624	34.619	5.833	4.736	2.067	738.6	6.228
724.1	6.440	34.738	34.607	5.600	4.864	1.937	726.6	6.371
713.6	6.501	34.804	34.624	5.567	4.864	1.913	716.0	6.433
703.2	6.545	34.838	34.622	5.633	4.864	1.917	705.6	6.478
692.2	6.631	34.913	34.624	5.733	4.992	1.950	694.6	6.564
682.0	6.667	34.946	34.629	5.467	4.992	1.853	684.4	6.601
671.2	6.731	35.001	34.630	5.267	4.992	1.789	673.6	6.666
659.1	6.756	35.020	34.632	5.233	5.120	1.746	661.5	6.692
871.9	5.351	33.813	34.602	6.700	4.480	1.750	874.5	5.275
860.5	5.409	33.861	34.602	6.533	4.480	2.430	863.1	5.333
850.3	5.521	33.959	34.604	6.533	4.480	2.402	852.9	5.446
840.2	5.597	34.022	34.603	6.600	4.480	2.400	842.8	5.522

828.4	5.618	34.038	34.605	6.567	4.608	2.382	831.0	5.544
818.1	5.730	34.132	34.602	6.567	4.608	2.380	820.7	5.656
807.5	5.787	34.176	34.599	6.567	4.608	2.343	810.1	5.714
797.2	5.909	34.284	34.602	6.433	4.608	2.303	799.7	5.836
786.3	5.974	34.342	34.606	6.333	4.608	2.254	788.8	5.902
776.0	6.011	34.370	34.605	6.433	4.608	2.273	778.5	5.940
764.5	6.059	34.412	34.609	6.233	4.736	2.218	767.0	5.989
753.6	6.113	34.458	34.611	6.033	4.736	2.134	756.1	6.043
739.7	6.277	34.608	34.619	6.000	4.736	2.078	742.2	6.208
728.4	6.375	34.694	34.621	5.600	4.736	1.950	730.9	6.306
717.6	6.479	34.784	34.622	5.633	4.864	1.929	720.0	6.411
705.4	6.533	34.828	34.622	5.567	4.864	1.882	707.8	6.466
693.5	6.618	34.902	34.624	5.767	4.864	1.941	695.9	6.551
681.9	6.668	34.946	34.628	5.467	4.992	1.853	684.3	6.602
670.3	6.735	35.004	34.630	5.300	5.120	1.785	672.7	6.670
657.5	6.766	35.028	34.631	5.233	5.120	1.746	659.9	6.702
646.5	6.844	35.096	34.633	5.200	5.248	1.727	648.8	6.781
639.7	6.849	35.097	34.633	5.067	5.376	1.698	642.0	6.787

**** ROSETTE TRIP AT 10-JUN-80 03:18:48 AVERAGED RAW DATA:

	P	T	C	O2	TO2	
RAW DATA:	644.0	6.849	35.098	5.136	5.312	12 PTS AVERAGED
STD. DEV:	0.9	0.0005	0.0006	0.0164	0.0640;	SALT= 34.633, O2= 1.672

630.0	6.859	35.102	34.633	5.167	5.504	1.688	632.3	6.798
619.6	6.935	35.174	34.641	5.167	5.504	1.703	621.9	6.874
607.7	6.976	35.204	34.638	5.100	5.632	1.684	610.0	6.916
596.9	6.991	35.214	34.639	5.100	5.632	1.656	599.2	6.932
584.8	7.037	35.250	34.638	4.933	5.632	1.603	587.1	6.979
573.1	7.051	35.258	34.639	4.967	5.760	1.612	575.4	6.995
561.9	7.076	35.280	34.643	4.933	5.760	1.594	564.1	7.021
550.1	7.118	35.311	34.641	5.033	5.760	1.600	552.3	7.064
537.3	7.361	35.545	34.659	5.200	5.888	1.629	539.5	7.307
526.3	7.490	35.655	34.655	5.133	5.888	1.628	528.5	7.437
515.9	7.657	35.820	34.673	4.900	5.888	1.540	518.1	7.604
502.0	7.822	35.964	34.671	3.833	6.016	1.214	504.2	7.770
490.7	8.192	36.284	34.654	3.633	6.016	1.111	492.8	8.140
480.5	8.279	36.390	34.685	3.633	6.016	1.092	482.6	8.227
469.7	8.307	36.410	34.684	3.700	6.016	1.108	471.8	8.257
457.8	8.510	36.592	34.683	4.100	6.144	1.167	459.9	8.460
446.4	8.818	36.895	34.707	5.467	6.272	1.522	448.5	8.768
433.6	9.042	37.100	34.709	5.833	6.400	1.684	435.7	8.993
431.7	9.154	37.212	34.718	5.400	6.656	1.548	433.8	9.105

**** ROSETTE TRIP AT 10-JUN-80 03:23:10 AVERAGED RAW DATA:

	P	T	C	O2	TO2	
RAW DATA:	432.7	9.161	37.219	5.489	6.581	12 PTS AVERAGED
STD. DEV:	1.0	0.0053	0.0073	0.0314	0.0631;	SALT= 34.718, O2= 1.543

419.2	9.195	37.249	34.722	5.233	6.912	1.534	421.3	9.147
407.0	9.255	37.314	34.737	4.933	7.040	1.401	409.0	9.209
395.4	9.519	37.548	34.729	5.400	7.040	1.442	397.4	9.473
385.2	9.691	37.722	34.747	5.667	7.168	1.516	387.2	9.646
371.7	9.946	37.972	34.764	6.267	7.296	1.695	373.7	9.902
359.9	10.125	38.144	34.773	5.700	7.296	1.554	361.9	10.082
349.7	10.376	38.400	34.797	6.467	7.424	1.646	351.7	10.333

339.2	10.529	38.543	34.800	6.967	7.424	1.838	341.1	10.487
328.8	10.703	38.716	34.813	6.700	7.552	1.787	330.7	10.662
317.1	10.858	38.870	34.825	6.467	7.680	1.682	319.0	10.818
315.7	10.864	38.874	34.824	6.367	7.936	1.647	317.6	10.824

**** ROSETTE TRIP AT 10-JUN-80 03:25:59 AVERAGED RAW DATA:

	P	T	G	O2	TO2	
RAW DATA:	316.9	10.867	38.877	6.317	7.989	12 PTS AVERAGED
STD. DEV:	0.2	0.0009	0.0009	0.0373	0.0631;	SALT= 34.825, O2= 1.639

304.6	10.892	38.905	34.834	6.467	8.320	1.660	306.5	10.854
292.4	11.081	39.093	34.848	6.400	8.576	1.623	294.3	11.044
281.8	11.169	39.168	34.844	6.467	8.576	1.621	283.7	11.133
270.8	11.349	39.362	34.871	5.867	8.704	1.475	272.7	11.314
259.8	11.468	39.475	34.875	5.667	8.832	1.386	261.6	11.434
248.3	11.513	39.515	34.877	5.867	8.960	1.423	250.1	11.481
238.1	11.540	39.536	34.877	5.933	8.960	1.431	239.9	11.509
227.2	11.569	39.559	34.877	6.333	9.088	1.514	229.0	11.539
220.5	11.573	39.559	34.876	6.567	9.472	1.594	222.3	11.544

**** ROSETTE TRIP AT 10-JUN-80 03:28:42 AVERAGED RAW DATA:

	P	T	G	O2	TO2	
RAW DATA:	222.7	11.573	39.560	6.514	9.483	12 PTS AVERAGED
STD. DEV:	0.4	0.0003	0.0005	0.0346	0.0631;	SALT= 34.877, O2= 1.583

210.0	11.652	39.636	34.882	6.700	9.856	1.592	211.8	11.625
200.9	11.794	39.777	34.891	7.467	9.984	1.766	202.7	11.767

**** ROSETTE TRIP AT 10-JUN-80 03:30:01 AVERAGED RAW DATA:

	P	T	G	O2	TO2	
RAW DATA:	202.5	11.794	39.775	7.506	10.037	12 PTS AVERAGED
STD. DEV:	0.7	0.0032	0.0036	0.0650	0.0631;	SALT= 34.889, O2= 1.766

189.9	11.802	39.749	34.861	9.533	10.240	2.143	191.7	11.777
179.4	11.976	39.921	34.871	10.867	10.368	2.572	181.1	11.952
167.6	12.001	39.894	34.826	10.800	10.368	2.425	169.3	11.979
161.2	12.314	40.113	34.751	15.200	10.496	3.487	162.9	12.292

**** ROSETTE TRIP AT 10-JUN-80 03:31:32 AVERAGED RAW DATA:

	P	T	G	O2	TO2	
RAW DATA:	163.3	12.304	40.101	15.264	10.560	12 PTS AVERAGED
STD. DEV:	0.4	0.0365	0.0321	0.0287	0.0640;	SALT= 34.748, O2= 3.482

149.4	13.863	41.555	34.708	16.100	10.752	3.466	151.1	13.841
143.6	14.527	42.224	34.733	16.333	10.880	3.435	145.3	14.505
138.4	15.399	43.129	34.784	16.367	10.880	3.372	140.1	15.377
138.9	15.285	42.965	34.736	16.567	11.008	3.380	140.6	15.263

**** ROSETTE TRIP AT 10-JUN-80 03:47:21 AVERAGED RAW DATA:

	P	T	G	O2	TO2	
RAW DATA:	140.4	15.383	43.062	16.611	11.051	12 PTS AVERAGED
STD. DEV:	0.4	0.1189	0.1254	0.2654	0.0603;	SALT= 34.737, O2= 3.372

132.8	16.504	44.193	34.765	17.833	11.392	3.486	134.5	16.482
129.4	19.048	46.729	34.767	21.967	11.904	3.669	131.1	19.024

**** ROSETTE TRIP AT 10-JUN-80 03:48:25 AVERAGED RAW DATA:

	P	T	G	O2	TO2	
RAW DATA:	130.6	20.304	48.043	20.586	11.936	12 PTS AVERAGED
STD. DEV:	0.2	0.1823	0.3601	2.3356	0.0924;	SALT= 34.805, O2= 3.855

123.4	22.576	50.529	34.938	27.167	12.672	4.026	125.1	22.550
117.7	23.488	51.598	35.037	29.100	12.800	4.346	119.4	23.462
117.6	23.320	51.354	34.984	29.767	13.568	4.242	119.3	23.295

**** ROSETTE TRIP AT 10-JUN-80 03:49:33 AVERAGED RAW DATA:

	P	T	G	O2	TO2	
RAW DATA:	119.2	23.449	51.474	29.808	13.888	12 PTS AVERAGED
STD. DEV:	0.3	0.1751	0.1978	0.5888	0.1109;	SALT= 34.973, O2= 4.402

112.2	23.952	51.969	34.955	33.433	15.232	4.673	113.8	23.927
103.6	24.455	52.522	34.980	35.700	15.488	4.918	105.2	24.432
101.3	24.727	52.810	34.984	36.400	16.384	4.998	102.9	24.704

**** ROSETTE TRIP AT 10-JUN-80 03:50:43 AVERAGED RAW DATA:

	P	T	G	O2	TO2	
RAW DATA:	103.4	24.680	52.743	37.514	16.629	12 PTS AVERAGED
STD. DEV:	0.6	0.0632	0.0739	0.3224	0.1221;	SALT= 34.971, O2= 4.937

95.6	25.764	53.961	35.035	41.167	17.920	5.113	97.2	25.742
89.4	26.795	54.991	34.997	45.100	18.048	5.347	91.0	26.773
84.0	27.606	55.814	34.975	49.633	18.304	5.699	85.6	27.585
77.6	27.924	56.062	34.915	52.267	18.432	6.106	79.2	27.904
69.9	28.264	56.396	34.900	53.267	18.688	6.219	71.5	28.246
68.0	28.127	56.240	34.892	56.167	26.496	5.964	69.6	28.110

**** ROSETTE TRIP AT 10-JUN-80 03:57:30 AVERAGED RAW DATA:

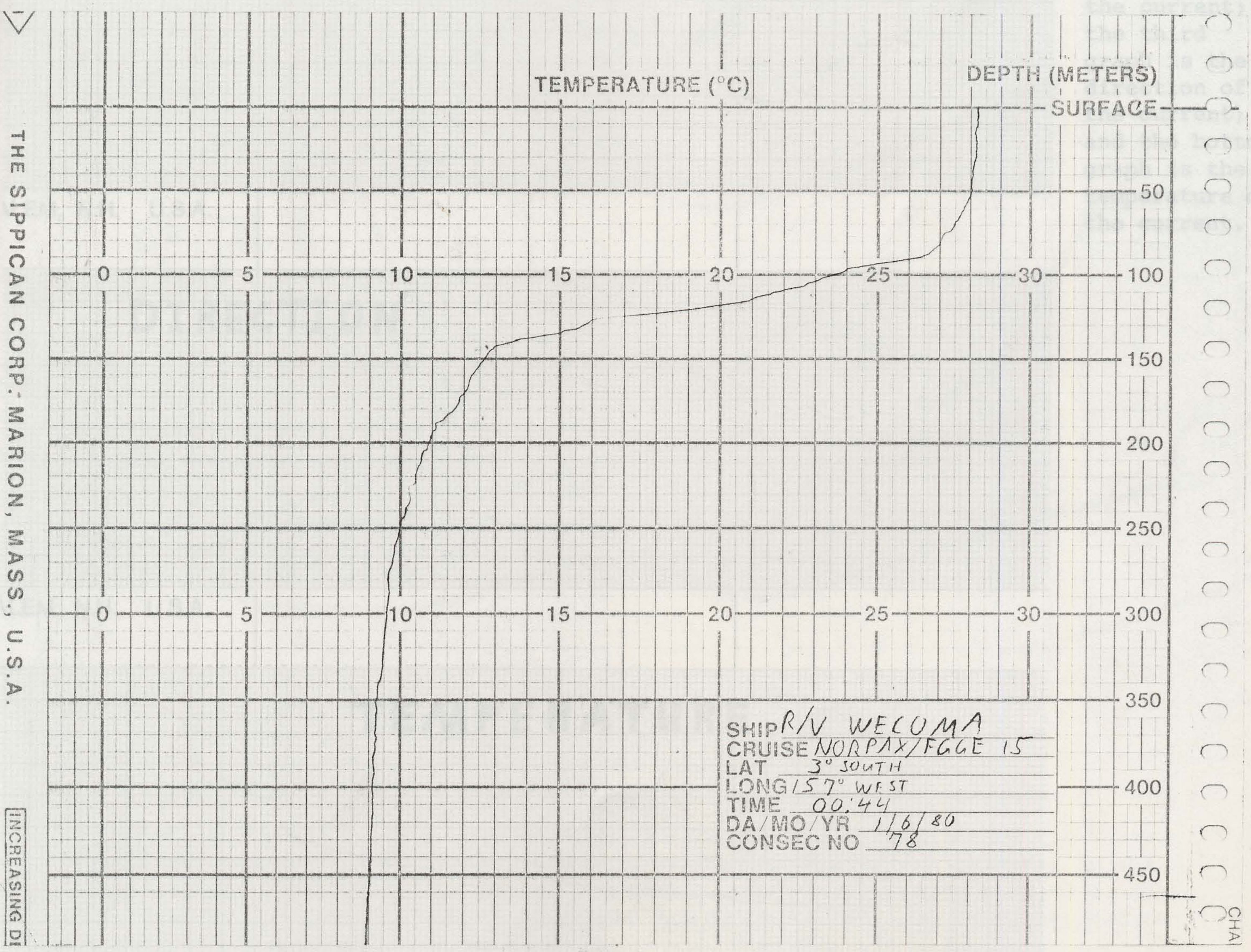
	P	T	G	O2	TO2	
RAW DATA:	69.9	28.122	56.236	56.950	26.485	12 PTS AVERAGED
STD. DEV:	0.4	0.0031	0.0023	0.4111	0.0631;	SALT= 34.894, O2= 5.896

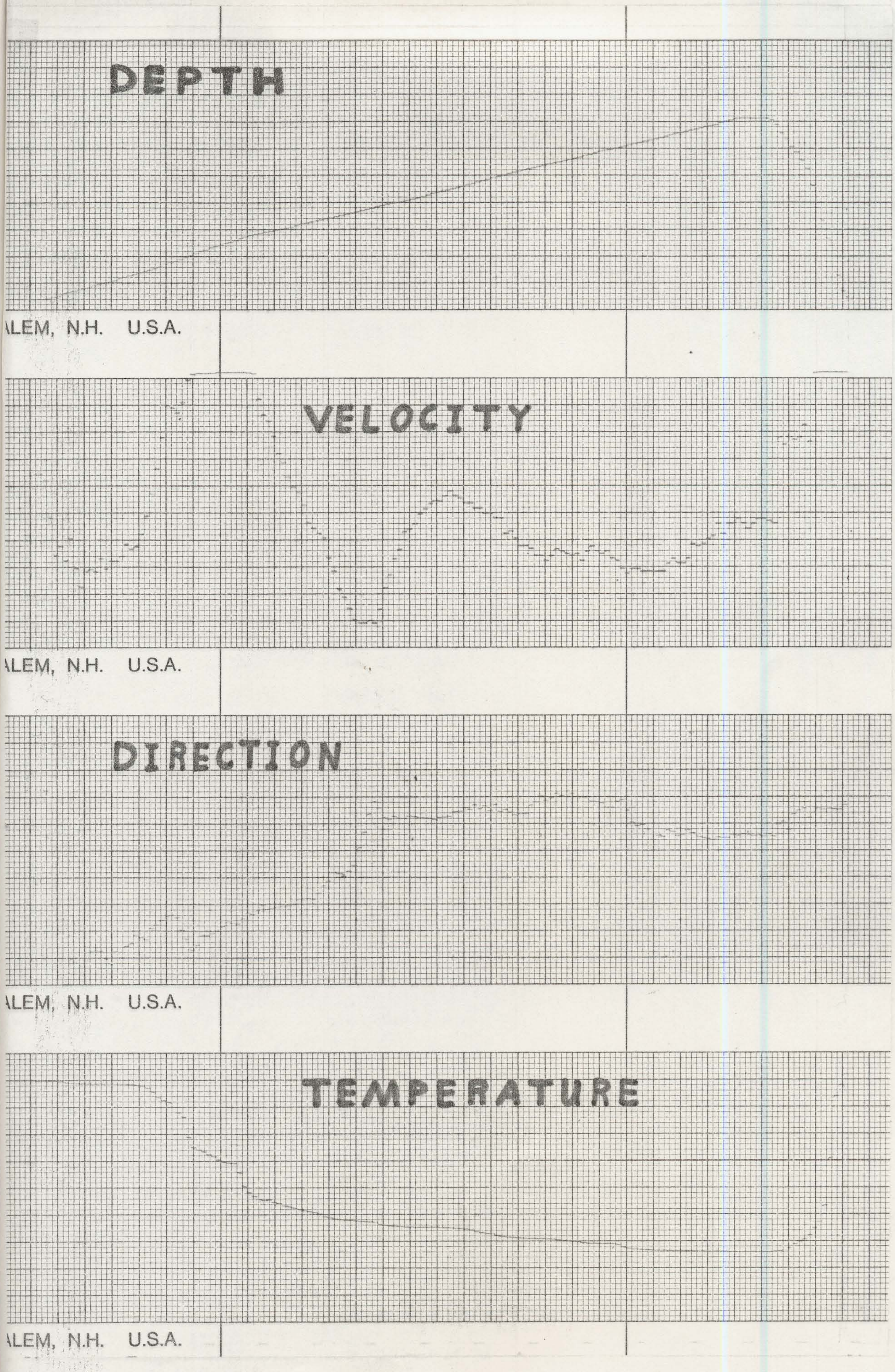
63.1	28.226	56.328	34.882	59.000	27.008	6.076	64.7	28.210
55.8	28.304	56.425	34.894	61.100	27.008	6.128	57.4	28.290
49.1	28.331	56.456	34.898	61.267	27.008	6.352	50.7	28.318
43.5	28.327	56.446	34.896	61.100	27.136	6.388	45.1	28.316
37.4	28.349	56.475	34.901	62.133	27.008	6.375	39.0	28.339
31.8	28.352	56.476	34.902	62.233	27.264	6.366	33.3	28.344
26.1	28.349	56.470	34.901	61.267	27.264	6.415	27.6	28.342
19.8	28.350	56.470	34.902	62.867	27.264	6.446	21.3	28.345
13.5	28.348	56.464	34.901	61.500	27.264	6.439	15.0	28.345
12.0	28.346	56.462	34.902	61.700	27.264	6.279	13.5	28.343
8.5	28.344	56.459	34.902	62.400	27.392	6.303	10.0	28.342
7.1	28.346	56.460	34.902	62.300	27.392	6.352	8.6	28.344
4.4	28.344	56.457	34.902	62.600	27.264	6.346	5.9	28.343
2.3	28.345	56.455	34.901	60.900	27.264	6.301	3.8	28.344
0.6	28.343	56.454	34.902	62.500	27.392	5.966	2.1	28.343
0.3	27.120	0.744	-0.304	47.467	27.520	9.613	1.8	27.120

* * * * * * * * * * * * * * * * * * * *

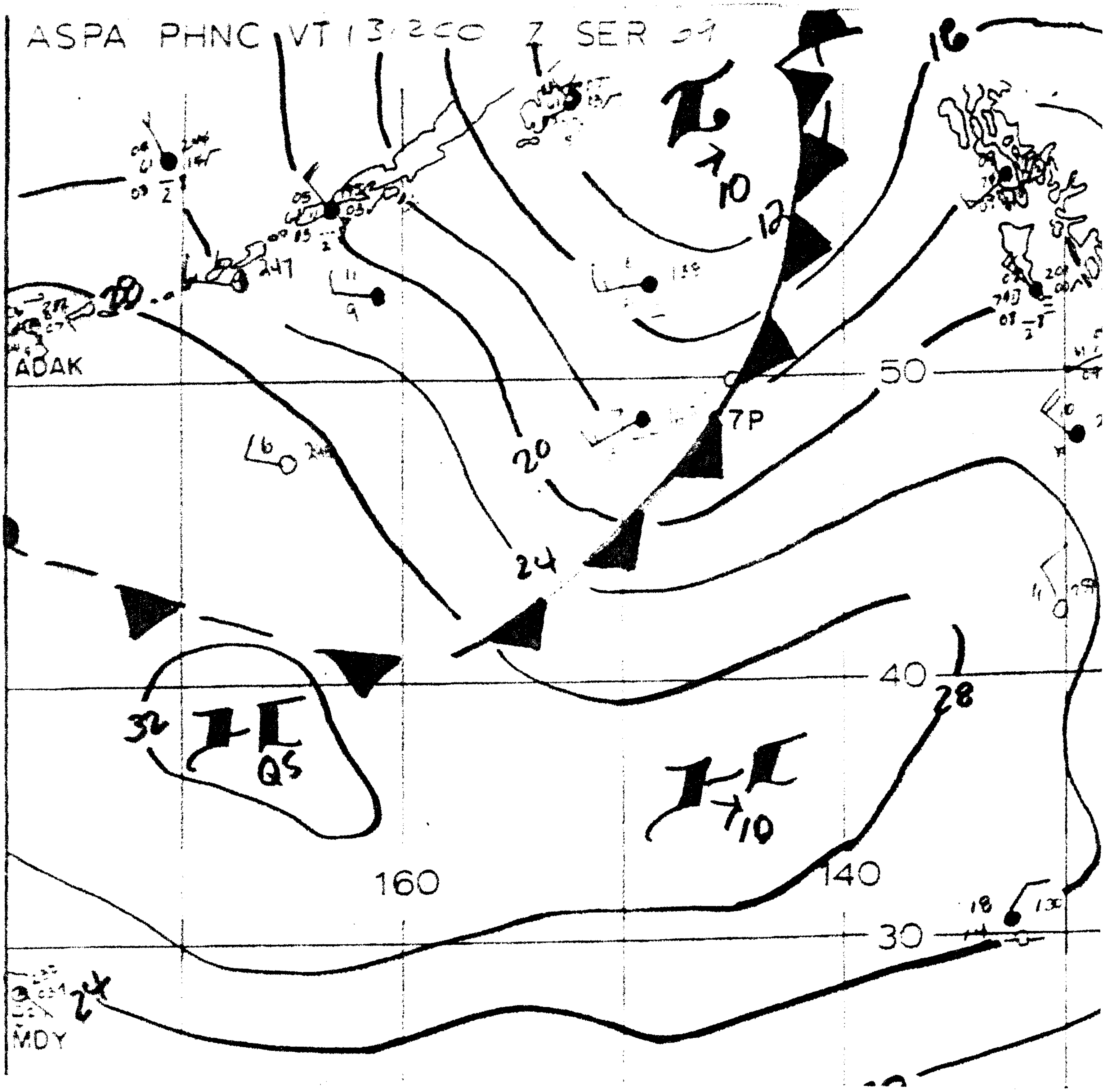
```
        END OF STATION 25 CAST 1

    691 LEVELS, EQUIVALENT TO 21130 BYTES, ON TAPE 2 FILE 7
TERMINATED 10-JUN-80 04:00:31

RDSTRIPS DATA SAVED
TAPE WRITTEN O.K.
EOF FOUND ON FILE 7
TAPE CAN BE READ SUCCESSFULLY (THIS TIME)
```

The graph below is a sample XBT temperature profile. The temperature is recorded as a curve that is a function of depth.





On the left is a sample current profile. The uppermost graph is the depth reading; the second graph is the velocity of the current; the third graph is the direction of the current; and the bottom graph is the temperature of the current.



The above weather map is one of the daily weather transmissions received by the weather receiver onboard the R/V Wecoma and then electronically reproduced as a map. This particular weather map depicts Hurricane Agatha which had just been upgraded to the status of "hurricane".

Bibliography.

Atlas of Hawaii by the University of Hawaii Department of Geography, publisher: The University Press of Hawaii,Honolulu,Hawaii,1973.

Cartographic Handbook of French Polynesia by Jean Fages, published in: Societe des Oceanistes Dossier 19,Paris,France,1975.

Chemical Oceanography by Wallace S. Broecker, publisher: Harcourt Brace Jovanovich, Inc.,New York,New York,1974

El Nino - The Dynamic Response of the Equatorial Pacific Ocean to Atmospheric Forcing by Klaus Wyrtki, published in: Journal of Physical Oceanography,vol.5,pgs.572-584, 1975.

Equatorial Currents in the Pacific 1950-1970 and Their Relationships to the Tradewinds by Klaus Wyrtki, published in: Journal of Physical Oceanography,vol.4,pgs.372-380, 1974.

Equatorial Currents: Observations and Theory by Ants Leetma,Julian McCreary,Jr.,and Dennis W. Moore, to be published in The Ocean Environment by the Massachusetts Institute of Technology Press,Massachusetts,1980.

Equatorial Undercurrent: Measurements and Theories by S.G.H. Philander, publisher: Geophysical Fluid Dynamics Program,Princeton,New Jersey.

Guide to Common Shipboard Expendable Bathythermograph (SXBT) Recording Malfunctions by Stephen M. Kroner and Barry P. Blumenthal, publisher: Naval Oceanographic Office, Bay St.Louis,Missouri,1978.

Instruction Manual for Polymode Surveying by Geosecs Operations Group/NSF, publisher: Scripps Institution of Oceanography,La Jolla,California,1977.

Law of the Sea: Neglected Issues by John King Gamble Jr., publisher: Law of the Sea Institute,University of Hawaii,Honolulu,Hawaii,1979.

Marine Scientific Research and the Third Law of the Sea Conference by Freedom of Ocean Science Task Group,Ocean Policy Committee,Commission on International Relations, and the Nation Research Council, publisher: National Academy of Sciences,Washington, D.C.,1976.

MFE 1000 Series Stripchart Recorders Manual by MFE Corporation,Salem,New Hampshire,1978.

Operating Manual for Recording Current Meter by Aanderaa Instruments,Bergen,Norway,1978.

Pet 2001-8 Personal Computer User Manual by Commodore Business Machines,Palo Alto,California,1978.

Predicting and Observing El Nino by Klaus Wyrtki,Edward Stroup,William Patzert,Robert Williams,and William Quinn, published in: Science,vol.191,pgs.343-346,1976.

Sea Level and the Seasonal Fluctuations of the Equatorial Currents in the Western Pacific by Klaus Wyrtki, published in: Journal of Physical Oceanography,vol.4,pgs. 91-103,1974.

Sea Level During the 1972 El Nino by Klaus Wyrtki, published in: Journal of Physical Oceanography,vol.7,pgs.779-787,1977.

Sony Stereo Taperecorder TC-377 by Sony Corporation,Korea.

Tektronics 4907 Installation Guide and Operations Manual by Tektronics,Beaverton,Oregon, 1979.

Tektronics Graphic System Reference Manual 4051 by Tektronics,Beaverton,Oregon,1976.

Tektronics Interactive Digital Plotter Users 4662 by Tektronics,Beaverton,Oregon,1976.

Teleconnections in the Equatorial Pacific Ocean by Klaus Wyrtki, published in: Science, vol.180,pgs.66-68,1973.

The New Pacific by the State of Hawaii Department of Planning and Economic Development, publisher: State of Hawaii Department of Planning and Economic Development,Honolulu, Hawaii,1980. (chart)

The Oceans by H.U. Sverdrup,Martin W. Johnson,and Richard H. Fleming, publisher: Prentice-Hall Inc.,Englewood Cliffs,New Jersey,1942.

The Pacific Islands (Revised Edition) by Douglas L. Oliver, publisher: The University Press of Hawaii,Honolulu,Hawaii,1975.

The Pacific Ocean by the Cartographic Division of the National Geographic Society, publisher: The National Geographic Society,Washington,D.C.,1963. (chart)

The Rand McNally Atlas of the Oceans by Rand McNally and Company, publisher: Rand McNally and Company,Chicago,Illinois,1977.

The Third U.N. Law of the Sea Conference (Report to the Senate) by Senators Claiborne Pell,Thomas McIntyre,Clifford Case,Charles McC. Mathias,Jr.,Ted Stevens,and Mike Gravel, publisher: U.S. Government Printing Office,Washington,D.C.,1975.

The Tradewind Field Over the Pacific Ocean by Klaus Wyrtki and Gary Meyers, published in: Journal of Applied Meterology,vol.15,pgs.698-704,1976.

United Nations International Law Commission by B.G. Ramchauan, publisher: Martinus Nijhoff/The Hague,Netherlands,1977.

Personal Discussions and Interviews

Arturo Cancela - Oceanographer for the Argentinian Naval Oceanographic Office,Argentina.

Robert Dennis - Project manager for the National Oceanic and Atmospheric Administration (NOAA),Washington,D.C..

Eric Firing - Oceanographer and director of the PCM experiment in the North Pacific Experiment/First Global GARP Experiment for the University of Hawaii.

Paul Frietag - Oceanographer for the Pacific Marine Experimental Laboratory (PMEL) which is a subgroup of the National Oceanic and Atmospheric Administration (NOAA),Seattle,Washington.

William LaFleur - Chief engineer/electronics technician on the R/V Wecoma.

Joyce Miller - Geologist and PCM technician for the Hawaii Institute of Geophysics, University of Hawaii,Honolulu,Hawaii.

James Schmidt - Oceanographic technician for Scripps Institution of Oceanography, La Jolla,California.

Edward Slater - Oceanographic technician for Scripps Institution of Oceanography, La Jolla,California.

"Sten" Stenfors - Communications engineer/electronics technician on the R/V Wecoma.

Bruce Taft - Oceanographer,researcher,and professor of oceanography for the University of Washington School of Oceanography,Seattle,Washington.

Preliminary data from the North Pacific Experiment/First Global GARP Experiment (NORPAX/FGGE) was also utilized in compiling this report.

SLIDES of the NORPAX/FGGE (North Pacific Experiment/First Global GARP Experiment) Hawaii - Tahiti Shuttle 1979 - 80.

These slides are to supplement the report titled An Observers Report of the NORPAX/FGGE Oceanographic Expedition Between Hawaii and Tahiti submitted by MOP student Bjørn Aune.

Slide #	Explanation of slide
1	The research vessel Wecoma from Oregon State University in Papeete Harbor, Tahiti, March 1980.
2	The research vessel Wecoma at Snug Harbor, Honolulu, Hawaii, February 1980.
3	The research vessel Wecoma taking onboard the pilot for entering Papeete Harbor. Moorea is in the background.
4	The dry laboratory (drylab) on the R/V Wecoma. This slide shows some of the computers, depth recorders, and PCM equipment.
5	The wet laboratory (wetlab) on the R/V Wecoma. This slide shows MOP student Athleen Clark working with an oceanographer from Scripps Institution of Oceanography doing chemical analysis of seawater.
6	Mop student Bjørn Aune "hard at work" in the PCM (Profiling Current Meter) section of the drylab.
7	Edward Slater of Scripps Institution of Oceanography explaining some of the equipment in the drylab to grammar school students in Tahiti.
8	The wetlab (in particular the nutrient analysis equipment). In the back-round is MOP student Athleen Clark and Edward Slater of Scripps.
9	Rick Van Woy of Scripps working on atmospheric gas sampling with a gas chromatograph.
10	A satellite tracking surface current drift buoy (apart).
11	Dr. Eric Firing of the Hawaii Institute of Geophysics and Jim Wells of Scripps working on the satellite buoy.
12	MOP student Cindy Kleh, Dr. Eric Firing of HIG, a guy from San Jose State, and a guy from Lamont Geological Observatory preparing a satellite buoy for launching.
13	The same gang of four launching the satellite buoy.
14	The satellite buoy in the water following the launch.
15	Last sight of the satellite buoy as the ship moves away.
16	The deep sea water sampling unit. MOP student Athleen Clark looking on in the background.
17	Preparing the deep sea sampling unit for a drop.
18	Preparing the wire cable to which the deep sea sampling unit is attached.
19	Lifting the deep sea sampling unit up to put over the side.
20	The deep sea sampling unit going over the side.
21	The deep sea sampling unit entering the water to be lowered 150 meters.
22	Night operations with the deep sea sampling unit.
23	Preparing the wire cable to which the deep sea sampling unit will be attached at night.
24	Lifting the deep sea sampling unit up to put over the side at night.

Slide #	Explanation of slide
25	The deep sea sampling unit going over the side at night.
26	The CTD (Conductivity, Temperature, Depth) unit with Niskin bottles. The CTD unit measures the conductivity, oxygen content, temperature from which salinity is derived with depth.
27	The CTD unit going over the side.
28	The fantail (after deck) of the R/V Wecoma showing the deep sea sampling unit, the CTD unit, and the satellite buoy.
29	MOP students Athleen Clark and Bjørn Aune with other scientists and crew members relaxing in the evening on the fantail.
30	MOP student Bjørn Aune with the PCM (profiling Current Meter) hull.
31	MOP student Bjørn Aune repairing the PCM hull.
32	MOP student Bjørn Aune loading the PCM hull with an Aanderaa current meter in preparation for a drop.
33	MOP student Bjørn Aune being assisted by DR. Bruce Taft in putting the PCM unit over the side.
34	MOP student Bjørn Aune making a final check on the Aanderaa current meter before deploying it.
35	The PCM unit going over the side - with MOP student Bjørn Aune holding on to it to steady it.
36	Moored current meter recovery operations at the Equator.
37	Hoisting onboard some of the glass balls used as floats on the current meters.
38	Guiding some of the glass balls onto the deck so that they can be detached.
39	The entire array of glass balls for one current meter array being brought on deck.
40	A deep sea sediment trap being brought up.
41	Setting the sediment trap down on deck (carefully).
42	MOP student Bjørn Aune at the helm guiding the line from the current meters as it comes up onto the winch.
43	An aeronometer used for determining wind speed and wind direction.
44	MOP students Athleen Clark and Bjørn Aune along with scientists from Scripps and the University of Washington having a "welcome back to land drink" after 29 days at sea.
45	The petti-bone crane used for hoisting the many different oceanographic units into and out of the water, the hydrowinch used for deploying and recovering the PCM unit, and the trawling winch used for deploying and recovering the CTD unit and deep sea water sampling unit.
46	Another view of the same equipment from higher up.
47	View of the above equipment and the fantail, where a satellite buoy is lying, from the crows nest.
48	Another shot of the same subject as # 47.
49	The mast and crows nest of the R/V Wecoma where the meteorological data collecting equipment is situated.
50	The bow of the R/V Wecoma from the crows nest.
51	The R/V Wecoma encountering heavy seas.

Slide #	Explanation of slide
52	Another shot of the heavy seas.
53	The R/V Wecoma smashing through the heavy seas.
54	A 30 foot sea approaching the R/V Wecoma.
55	Water rushing down the deck after the 30 foot sea struck the vessel.
56	White-tip oceanic sharks in a frenzy (garbage had just been thrown over the side).
57	Another shot of a white-tip oceanic shark.
58	Dolphins racing the R/V Wecoma off Malden atoll
59	Booby in the water waiting for garbage to be thrown overboard.
60	Dolphin jumping out of the water off Malden atoll.
61	Shot of another dolphin jumping out of the water off Malden atoll.
62	Another booby waiting for garbage to be thrown overboard.
63	Sunset at sea.
64	The entire disc of the sun sitting on the horizon just prior to setting.
65	The sun setting on the horizon.
66	The sun halfway down.
67	Moonrise on a clear night. Note the brilliantly lighted planet below moon.
68	Moonset in the morning.
69	Malden atoll.
70	Malden atoll (note some of the structures).
71	Malden atoll.
72	Malden atoll.
73	The R/V Wecoma in Papeete Harbor, Tahiti.
74	The open market in downtown Papeete.
75	A river in interior Tahiti.
76	A black sand beach along the coast of Tahiti (northshore).
77	The surf breaking on the fringing reef off Moorea.
78	A sailing ship at anchor in Opunohu Bay, Moorea.
79	Aerial view of Uturoa, Raiatea. Uturoa is the second largest city in the Society Islands.
80	Outrigger canoe fishing boats in Uturoa Harbor. Tahaa in the background.
81	Jungle road on Raiatea.